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FOOD OF YOUNG-OF-THE-YEAR STRIPED BASS *(ROCCUS SAXATILIS)* IN THE SACRAMENTO-SAN JOAQUIN RIVER SYSTEM[1]

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INTRODUCTION

Young-of-the-year striped bass were studied to obtain a comprehensive knowledge of their year-round diet in the Sacramento-San Joaquin River system. This knowledge will help explain variations in migration, growth, and year-class strength, which will in turn aid in predicting the effects of future environmental changes on striped bass.

One such change will occur in the near future with the development of the California Water Plan. This plan will drastically alter water flow and salinity patterns in the Delta, thus changing the distribution and relative abundance of striped bass food organisms. Knowledge of the striped bass diet is necessary to insure adequate consideration for this species in the project design.

The movement of threadfin shad (*Dorosoma petenense*) into the Delta will bring about another change. These fish have dramatically altered other environments after becoming established (Kimsey *et al.*, 1957), and they have already started to migrate into the Delta from upstream reservoirs where they were introduced in 1959 and 1960 to provide more forage for warmwater game fish. Kimsey (1958) theorized that they might compete with small striped bass, stating, "Some competition for food would be certain to occur and there is a possibility that it would be severe. The overall effect on the striped bass population might be more serious than the more obvious predation problem."

Finally, this information may be useful in protecting the habitat from pollution by providing evidence of the value of many invertebrates which are usually first to feel its effects.

Previous striped bass food habit studies in California have identified the major food organisms consumed by adults (Smith, 1896; Scofield, 1910; Scofield and Bryant, 1926; Scofield, 1928, 1931; Shapovalov, 1936; Hatton, 1940; and Johnson and Calhoun, 1952). The only prior information concerning food habits of young-of-the-year bass is from three local studies (Scofield and Bryant, 1926; Shapovalov, 1936; and

[1] Submitted for publication February 1963. This work was performed as part of Dingell-Johnson Project California F-9-R, "A Study of Sturgeon and Striped Bass", supported by Federal Aid to Fish Restoration funds.
[2] Now with the California Department of Employment.

Hatton, 1940), which do not describe the general food habits of the population. The stomach contents of approximately 2,500 young-of-the-year striped bass collected between 1956 and 1961 were examined to fill this void. The data are summarized in this paper.

DESCRIPTION OF STUDY AREA

Striped bass inhabit approximately 1,000 miles of waterways in the Sacramento-San Joaquin River system, plus San Pablo and San Francisco bays, and the Pacific Ocean off the coast of Central California. Young-of-the-year bass are concentrated primarily in the Sacramento-San Joaquin Delta and San Pablo Bay (Figure 1). This area is bounded roughly by Sacramento on the north, Stockton to the east, Tracy to the south, and San Pablo Bay to the west.

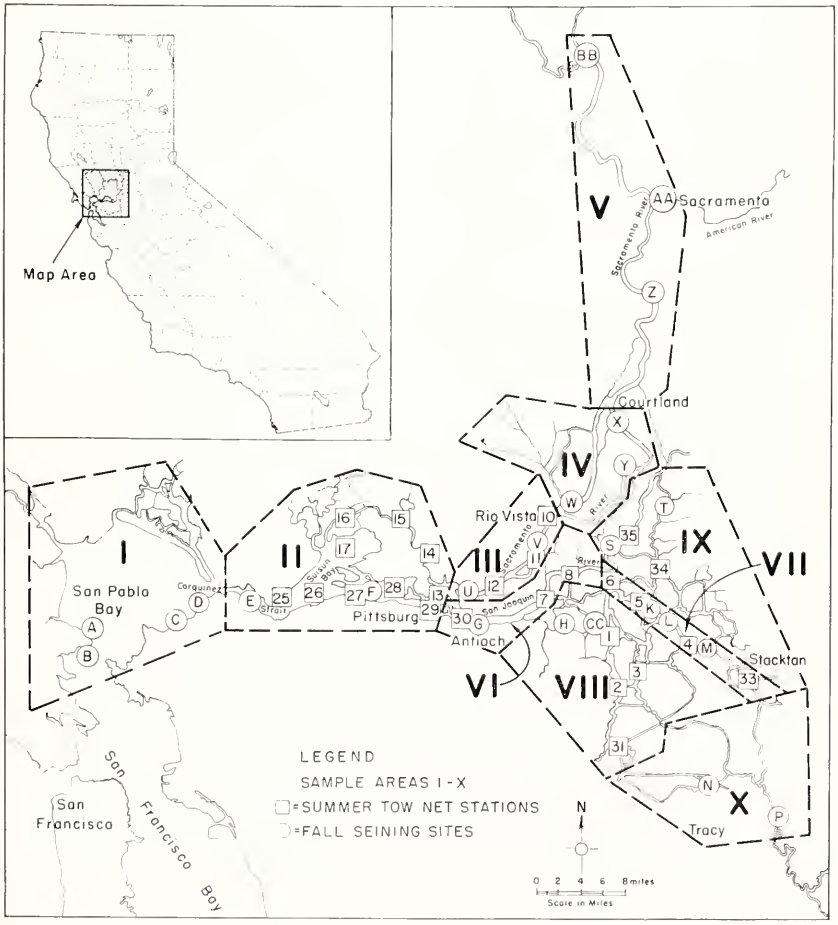

FIGURE 1. The lower Sacramento-San Joaquin River system showing areas with tow net and seining stations.

This entire area is estuarine in nature. Flow reversals, as a result of tidal action, occur regularly as far upstream as Courtland on the Sacramento River and Stockton on the San Joaquin River. On maximum ebb tides, water velocities approach 7.5 feet per second in Carquinez Strait (U.S. Dept. of Commerce). Above the confluence of the two rivers, water velocities reach a maximum of 3 to 4 feet per second. Water velocities in the Sacramento River channel are slightly greater than in the other more meandering waterways of the Delta. In recent years, the Sacramento River has supplied over 65 percent of the total flow to the Delta (California Department of Water Resources, 1959-1962a; and unpublished data).

Water salinity ranges from nearly sea water in San Pablo Bay to fresh water in the middle and upper Delta. The maximum encroachment of 1,000 ppm of chlorides is usually a few miles above Antioch during the summer and fall, but winter and spring runoff forces this salinity line down to Suisun Bay (U.S. Department of the Interior, 1957-1962). Waters above the confluence of the two rivers are essentially fresh for most of the year.

While flowing through the rich agricultural central valley of California, both rivers become laden with nutrients and are quite turbid upon entering the Delta. Secchi disk measurements at bass collecting sites during the summer were consistently less than 1 foot. In San Pablo Bay, the turbidity is reduced by sea water dilution.

The physical environmental characteristics, briefly described here, influence the distribution and abundance of potential striped bass food organisms, and hence, affect striped bass food habits.

METHODS

Young-of-the-year striped bass were collected in conjunction with other field activities between 1956 and 1961. Most summer collections were made with a tow net in the course of spawning success surveys (Harold K. Chadwick, MS.). All of the fall and the few winter and spring collections were made by seining.

All fish were preserved in 10 percent formalin for stomach examination at a later date.

Fork lengths of bass were measured in tenths of inches and the fish were divided into three groups—bass smaller than 1 inch, which were collected primarily in June and the first few weeks in July; bass 1 inch long or longer, which were taken in June, July and August; and bass from 2 to over 4 inches long, which were taken in September, October, and November.

Approximately 10 fish were examined from each sample. The number examined depended on the number of fish collected and the uniformity of the stomach contents. Bass over 0.4 inches long were dissected and examined under a dissecting microscope. Smaller fish were pressed between a microscope slide and cover slip and examined under a compound microscope. Since these small fish were transparent, their food could be identified easily without dissection.

Only organisms found in the esophagus and stomach were recorded, although remains in the intestines were occasionally useful in identifying remains in the stomach. In stomachs containing many copepods, the

total number was estimated by projecting counts of one-fourth or one-half of the contents. Comparison of these estimates with actual counts disclosed little error.

Stomach contents were summarized by frequency of occurrence (percentage of all stomachs containing food which contained a given food item) and the numerical method (the total number of a species divided by the total number of stomachs containing food). Volumetric or gravimetric measurements were not practical, since the stomachs contained such small amounts.

Plankton samples gathered throughout the study area served as a reference collection. The copepods, *Pseudodiaptomus euryhalinus* and

TABLE 1

Collecting Areas and Stations for Young-of-the-Year Striped Bass (1956-1961)

		Summer collection localities (Tow netting)		*Fall collection localities (Seining)*	
Area	*Description*	*Station*	*No. of fish*	*Station*	*No. of fish*
I.	San Pablo Bay			D	28
				C	16
II.	Sacramento River from Carquinez Strait to Pittsburg and Montezuma Slough	25	18	E	33
		17	56	F	30
		27	20		
		28	62		
		13	72		
		29	75		
		14	31		
		15	68		
		16	86		
III.	Sacramento River from Pittsburg to Rio Vista	12	62	U	24
		11	111	V	62
		10	68		
IV.	Sacramento River from Rio Vista to Courtland; and Steamboat Slough			Y	41
				W	38
				X	31
V.	Sacramento River from Courtland to the Feather River			Z	25
				AA	29
				BB	1
VI.	San Joaquin River from Pittsburg to the mouth of the Mokelumne River	30	110	G	45
		7	92		
		8	82		
VII.	San Joaquin River from mouth of the Mokelumne River to Stockton	6	86	K	30
		5	78	L	31
		4	65	M	30
		33	5		
VIII.	Sloughs south of San Joaquin River	1	120	H	24
		2	97	I	41
		3	66		
		31	33		
IX.	Mokelumne River and sloughs between the San Joaquin and Sacramento rivers			S	30
				T	13
X.	San Joaquin River above Mossdale; and Salmon Slough			N	27
				P	29

Acartia clausii, were identified as *Pseudodiaptomus* until late in the study. Therefore, they could not be separated in the summaries.

The relative rates of digestion of the principal food organisms (copepods, *Neomysis mercedis,* and *Corophium spinicorne*) were also determined. This information was needed to evaluate any bias arising from differences in digestion rates.

For these experiments, bass 2.5 to 4.5 inches long were collected by seining and held in an outdoor tank. They were transferred, 15 at a time, to a 20-gallon aquarium and held without food for one week. The organism to be tested was introduced into this tank, and the bass were allowed to feed for 20 minutes, except when all organisms were consumed in a shorter time. The bass were then placed in a clean tank and one was killed every half hour and its stomach contents examined. Organisms in the stomach were compared with preserved specimens to aid in denoting changes. The water temperature was 61° F throughout the experiments.

RESULTS

To simplify our data presentation, and to show variation in the food habits of young-of-the-year bass, collecting sites were grouped into 10 major ecological areas, based upon differences in bass food habits, and differences in the physical characteristics of the environment (Figure 1, Table 1). Areas I, IV, V, IX and X are believed to be of minor importance to young-of-the-year bass during the summer, and no bass were collected there. Fall collections were obtained from all 10 areas.

SUMMER DIET

During the summer, bass food habits varied by area and by size of fish.

In the Sacramento River below Pittsburg, *Neomysis* was the most important food of all size groups (Table 2). Copepods were second, with

TABLE 2

Stomach Contents of Young-of-the-Year Striped Bass in the Sacramento River between Carquinez Strait and Pittsburg (Area II), 1956-1961

Food item	Summer (June-August)				Fall (September-November)	
	0.1 - 1.0 inch bass (108 bass containing food)		1.1 - 3.0 inch bass (297 bass containing food)		2.0 - 4.5 inch bass (58 bass containing food)	
	Percentage frequency of occurrence	Number per stomach	Percentage frequency of occurrence	Number per stomach	Percentage frequency of occurrence	Number per stomach
Neomysis	55	1.6	85	5.8	77	13
Corophium	1	trace	18	0.6	14	0.4
Cladocera	2	trace	4	0.3	0	0
Copepods	41	0.8	19	6.4	45	31
Pseudodiaptomus and/or *Acartia*	4	0.1	3	0.9	26	14
Eurytemora	29	0.6	15	1.7	41	17
Cyclops	0	0	3	0.6	0	0
Diaptomus	0	0	6	2.8	0	0

Eurytemora and *Pseudodiaptomus* or *Acartia* the most common genera. *Corophium* was eaten frequently by bass over 1 inch long.

From Pittsburg to Rio Vista on the Sacramento River and to the mouth of the Mokelumne River on the San Joaquin River, copepods and *Neomysis* ranked first and second in frequency of occurrence in bass 1 inch long or shorter, while the order was reversed in bass over 1 inch long (Tables 3 and 4). *Eurytemora, Diaptomus,* and *Cyclops* were the most common copepod genera. The frequency of occurrence of cladocera and *Corophium* was higher in these areas than in downstream areas.

On the San Joaquin River from the mouth of the Mokelumne River to Stockton and in the sloughs south of the San Joaquin River, the importance of *Neomysis* declined markedly, while copepods and cladocerans became more important in the bass' diet (Tables 5 and 6). *Diaptomus* and *Cyclops* were the most common copepods.

Other organisms were of minor importance in the bass' diet. *Crago* and crab zoea were found in bass collected in Montezuma Slough and Suisun Bay. Tendipedid larvae and pupae were eaten by bass in the fresh water of the Sacramento and San Joaquin rivers. Fish remains were found in two bass. A bass 1.6 inches long, collected at Station 5 in June 1961, contained what was probably a bass 0.2 inches long. Another bass, 2.1 inches long, caught at Station 10 in August 1961, contained an unidentified fish vertebra. Tule fragments (*Scirpus*) and other plant debris were in a number of bass stomachs.

In general, the percentage frequency of copepod occurrence was greater in small bass than large ones, while the frequency of occurrence of larger plankton, *Neomysis* and *Corophium,* was greater in larger bass. The occurrence of cladocera did not appear to be related to fish size. Larger bass generally had more organisms in their stomachs.

The influence of salinity on the relative abundance of copepod genera in the diet of bass was readily recognizable. At stations with a high mean salinity, *Eurytemora* was the dominant genus (Figure 2). As the salinity decreased upstream, the observed percentages of freshwater genera, *Diaptomus* and *Cyclops*, increased.

The percentage of the total bass population utilizing each food organism was estimated by multiplying the percentage of the bass population in each area [3] by the average percentage occurrence of the food item in all bass and totaling the percentages. These percentages of frequency of occurrence were: *Neomysis*, 59 percent; copepods, 50 percent; cladocerans, 23 percent; and *Corophium*, 12 percent. Since these estimates are based on tow net surveys which sampled only the major areas inhabited by young-of-the-year bass, the true picture would be slightly different.

FALL DIET

Bass food habits changed little in the fall in Areas II and III (Tables 2 and 3). The greatest changes were a marked increase in copepod consumption and decline of *Neomysis* in the San Joaquin River (Tables 4 and 5).

[3] During the summers of 1959-1961, the estimated fractions of the young bass population occurring in various areas were: Area II, 34 percent; Area III, 30 percent; Area VI, 18 percent; Area VII, 8 percent; and Area VIII, 10 percent (Harold K. Chadwick, MS.).

TABLE 3

Stomach Contents of Young-of-the-Year Striped Bass in the Sacramento River between Pittsburg and Rio Vista (Area III), 1956-1961

	Summer (June-August)				Fall (September-November)	
	0.1 - 1.0 inch bass (93 bass containing food)		1.1 - 3.0 inch bass (108 bass containing food)		2.0 - 4.5 inch bass (75 bass containing food)	
Food item	Percentage frequency of occurrence	Number per stomach	Percentage frequency of occurrence	Number per stomach	Percentage frequency of occurence	Number per stomach
Neomysis	49	1.0	80	6.3	83	7.1
Corophium	4	0.1	10	0.2	16	0.6
Cladocera	34	1.6	41	5.6	0	0
Copepods	61	3.2	52	75	20	37
Pseudodiaptomus and/or *Acartia*	0	0	0	0	1	0.3
Eurytemora	26	0.7	17	4.0	19	27
Cyclops	12	0.2	22	6.5	8	0.6
Diaptomus	2	trace	33	64	19	8.2
Tendipedid larvae	0	0	1	trace	1.4	trace
Tendipedid pupae	0	0	0	0	1.4	trace

TABLE 4

Stomach Contents of Young-of-the-Year Striped Bass in the San Joaquin River between Pittsburg and the Mouth of the Mokelumne River (Area VI), 1956-1961

	Summer (June-August)				Fall (September-November)	
	0.1 - 1.0 inch bass (71 bass containing food)		1.1 - 3.0 inch bass (183 bass containing food)		2.0 - 4.5 inch bass (44 bass containing food)	
Food item	Percentage frequency of occurrence	Number per stomach	Percentage frequency of occurrence	Number per stomach	Percentage frequency of occurrence	Number per stomach
Neomysis	48	1.1	86	6.1	34	1.5
Corophium	11	0.1	37	0.7	11	0.2
Cladocera	18	0.3	12	0.9	50	8.5
Copepods	56	1.6	34	23	84	299
Pseudodiaptomus and/or *Acartia*	0	0	3	0.5	0	0
Eurytemora	17	0.3	15	4.3	73	49
Cyclops	3	trace	4	12	64	215
Diaptomus	21	1.0	21	6.1	32	35
Tendipedid larvae	0	0	1	trace	2	0.1
Tendipedid pupae	0	0	0	0	2	0.1

TABLE 5

Stomach Contents of Young-of-the-Year Striped Bass in the San Joaquin River between the Mouth of the Mokelumne River and Stockton (Area VII), 1956-1961

	Summer (June-August)				Fall (September-November)	
	0.1 - 1.0 inch bass (89 bass containing food)		1.1 - 3.0 inch bass (124 bass containing food)		2.0 - 4.5 inch bass (91 bass containing food)	
Food item	Percentage frequency of occurrence	Number per stomach	Percentage frequency of occurrence	Number per stomach	Percentage frequency of occurrence	Number per stomach
Neomysis	16	0.4	32	2.3	0	0
Corophium	2	trace	16	0.4	27	0.8
Cladocera	39	1.4	48	11	30	11
Copepods	84	6.9	71	61	100	593
Eurytemora	10	0.2	12	0.4	15	2
Cyclops	44	1.8	20	17	100	239
Diaptomus	71	4.9	67	34	100	352
Tendipedid larvae	0	0	1	trace	1	trace
Tendipedid pupae	0	0	1	trace	0	0

TABLE 6

Stomach Contents of Young-of-the-Year Striped Bass in the Sloughs South of the San Joaquin River (Area VIII), 1956-1961

	Summer (June-August)				Fall (September-November)	
	0.1 - 1.0 inch bass (158 bass containing food)		1.1 - 3.0 inch bass (145 bass containing food)		2.0 - 4.5 inch bass (61 bass containing food)	
Food item	Percentage frequency of occurrence	Number per stomach	Percentage frequency of occurrence	Number per stomach	Percentage frequency of occurrence	Number per stomach
Neomysis	17	0.3	21	0.7	11	0.2
Corophium	10	0.1	32	0.7	95	7.8
Cladocera	39	0.9	56	11	7	0.2
Copepods	84	8.5	80	87	36	3.2
Pseudodiaptomus and/or *Acartia*	0	0	1	trace	0	0
Eurytemora	13	0.4	13	0.4	13	1.0
Cyclops	27	0.9	57	16	23	1.6
Diaptomus	62	6.9	74	70	21	0.6
Tendipedid larvae	0	0	0	0	3	trace

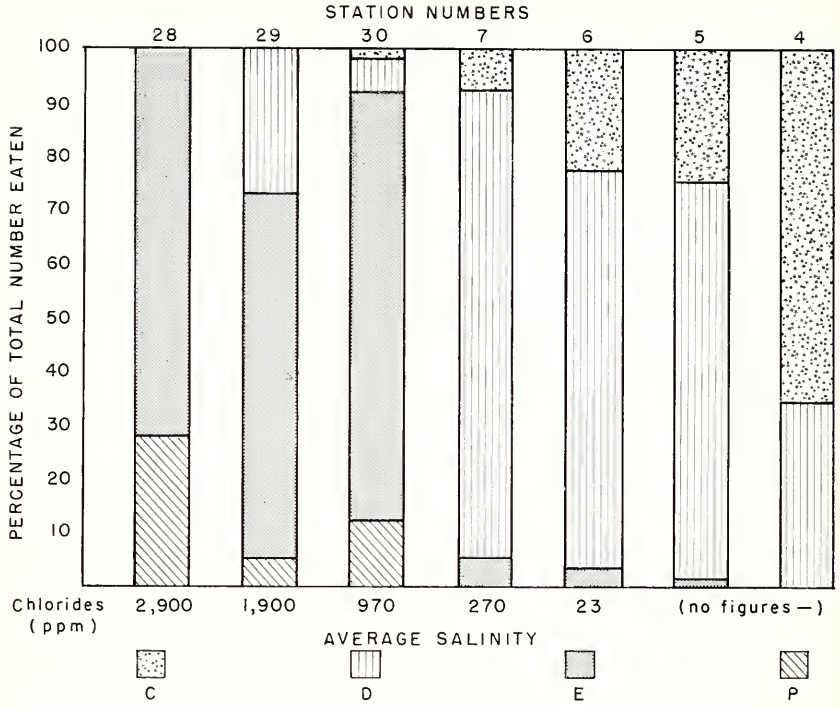

FIGURE 2. Relative importance of the copepods, *Pseudodiaptomus* and/ or *Acartia* (P), *Eurytemora* (E), *Diaptomus* (D), and *Cyclops* (C), in the diets of young-of-the-year bass from stations of various salinities in the Sacramento-San Joaquin Delta, 1959-1961.

In the sloughs south of the San Joaquin River, almost every bass contained *Corophium*, a considerable increase from the summer months (Table 6). The frequency of occurrence of all other organisms was less.

San Pablo Bay and the upper Sacramento and San Joaquin rivers were sampled only in the fall. In San Pablo Bay, amphipods (*Corophium* sp., *Anisogammarus*, and unidentified genera), *Nereis*, and *Neomysis* were the principal food organisms (Table 7). Over one-third of the bass contained clam sphons. Although these could not be identified, they were probably from *Macoma*, since these are the only clams there with long separate siphons. Copepods and isopods were also eaten by bass in this area.

TABLE 7

Stomach Contents of 42 Young-of-the-Year Striped Bass in San Pablo Bay (Area I), September-November, 1956-1960

Food item	*Percentage frequency of occurrence*	*Number per stomach*
Neomysis	31	0.6
Amphipods	45	2
Copepods	12	7.1
Pseudodiaptomus and/or *Acartia*	10	4.2
Unidentified Copepods	2	2.9
Isopods	10	0.2
Nereis	33	0.8

In upriver areas tendipedid larvae and pupae became increasingly important. In the Sacramento River above Freeport and in the San Joaquin River above Mossdale these dipterans were by far the most important food organisms (Table 8). They were also in a number of bass collected in the Mokelumne River and adjoining sloughs, but *Corophium* was the principal food item.

TABLE 8

Stomach Contents of Young-of-the-Year Striped Bass in the Upper Sacramento-San Joaquin Delta, September-November, 1956-1960

Food item	Sacramento River from Rio Vista to Courtland; and Steamboat Slough (Area IV) (108 bass containing food)		Sacramento River from Courtland to the Feather River (Area V) (46 bass containing food)		Mokelumne River and sloughs between the San Joaquin and Sacramento rivers (Area IX) (42 bass containing food)		San Joaquin River above Mossdale; and Salmon Slough (Area X) (56 bass containing food)	
	Percentage frequency of occurrence	Number per stomach	Percentage frequency of occurrence	Number per stomach	Percentage frequency of occurrence	Number per stomach	Percentage frequency of occurrence	Number per stomach
Neomysis	15	1.3	2	trace	5	0.1	11	0.3
Corophium	77	7.2	2	trace	93	6.9	23	1.1
Cladocera	8	0.7	5	0.1	2	0.4	4	0.1
Copepods	6	0.6	5	0.1	5	0.2	7	13
Cyclops	4	0.1	2	trace	5	0.1	7	8.4
Diaptomus	5	0.5	2	trace	2	trace	7	4.6
Tendepidid larvae	39	1.1	87	0.9	24	0.4	93	7.0
Tendepidid pupae	16	0.2	65	2.8	14	0.4	64	2.9

One 3-inch bass collected at Freeport contained a 1-inch American shad (*Alosa sapidissima*). A 2-inch bass collected at Mossdale contained a small crayfish.

The food habits of young-of-the-year bass during the fall could not be related to their distribution, since it has not been studied in detail.

WINTER AND SPRING DIET

Bass were collected at only three stations during the winter. Four bass collected in Steamboat Slough (Station W) on February 8, 1961, contained *Neomysis*, and one had a smelt, *Hypomesus*. Of 15 bass taken in February and March, 1961, in the Sacramento River (Station V), 14 contained *Neomysis*. One also contained *Corophium*, one had three tendipedid larvae, and one had fish remains. Seventy bass collected in the San Joaquin River (Station G) between December 1956 and April 1957 contained by frequency of occurrence: *Neomysis*, 73 percent; copepods, 58 percent; and *Corophium*, 23 percent.

During April 1957, bass were collected from five stations. Ten bass from Sacramento Point (Station U), and seven collected near Rio Vista (Station V) on the Sacramento River contained *Neomysis*. One bass from Sacramento Point contained a *Corophium*. Of four bass collected near Ryde (Station Y), three contained plant debris, one contained two tendipedid larvae and three *Neomysis*, and one contained insect

remains. Eleven bass from the San Joaquin River below Stockton (Station M) contained by frequency of occurrence: copepods, 91 percent; cladocerans, 45 percent; *Corophium*, 36 percent; and *Neomysis*, 27 percent. Three bass from Salmon Slough (Station N) all contained *Neomysis*, and one had three *Corophium*.

No major change is evident in the winter and spring diets of young bass; however, the limited number of collections inhibits making positive generalizations.

Short-term Variations

A year-round collection of bass from the San Joaquin River at Antioch presented an opportunity to determine short-term variations in stomach contents at a given station. Bass were collected frequently from September 1956 to April 1957, and in July and October 1957. The mean length of fish examined in July 1957, was 2.5 inches and the mean lengths of other samples ranged from 3.4 to 4.1 inches.

The bass fed on *Neomysis*, copepods, and *Corophium*. The percentage frequency of occurrence of these organisms varied widely from one sample to the next and seasonal changes were not evident (Figure 3).

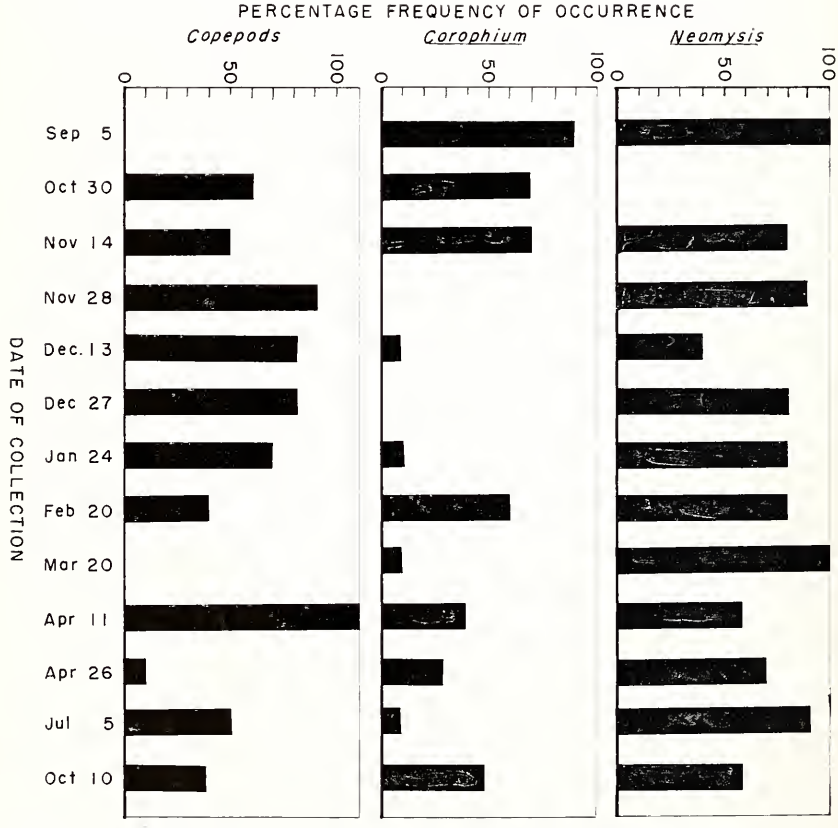

FIGURE 3. Percentage frequency of occurrence of three food organisms in the diets of young-of-the-year bass from the San Joaquin River at Antioch, 1956-57.

There was no decrease in the percentage of bass containing food nor in the volume of ingested food in the cooler months.

Rate of Digestion

Most copepods were still identifiable to genus after 1 hour. In 1½ hours, only two of the six eaten could be identified to genus, using a compound microscope. After 5 hours the general form of copepods could be recognized, but none could be identified. Only detritus remained after 6 hours.

Although the bodies of *Neomysis* broke down as rapidly as copepods, the characteristic compound eyes and eye stalks remained intact and were identifiable after 6 hours.

Corophium was quite resistant to digestive juices and could be identified for up to 8 hours. After this time all remains had passed into the large intestine, where digestion proceeds very rapidly. Surprisingly, three of seven *Corophium* were still moving after ½ hour in a bass's stomach. All three were moving their pleopods and one individual was moving its pereiopods and antennae and reacted to the touch of a probe. After 1½ hours, one individual was still moving its pleopods.

Although the results might be modified if the bass had not been starved before the experiment, they indicate there are important differences in the rates of digestion of the three primary food organisms. These differences resulted in overestimating the relative importance of *Corophium*, and to a lesser extent *Neomysis*, in the diet.

Distribution of Plankton Organisms

Only limited work on the distribution and habitat of invertebrates in the Sacramento and San Joaquin rivers has been done.

Corophium has generally been classified as a brackish-water organism (Light, 1954). Felice (1958) collected it from Antioch to San Pablo Bay over a salinity range of 0.4 to 19 parts per thousand. However, it has recently been abundant in the fresh waters of the Sacramento River up to Ryde and less common up to Wilkins Slough below Colusa (California Department of Water Resources, 1962b). We collected *Corophium* in fresh water in the San Joaquin River and adjoining sloughs as far upstream as Stockton.

Neomysis mercedis, a mysid shrimp, occurs in brackish-water bays, estuaries, and in fresh water (Light, 1954). In 1914, Tattersal (1932) collected *Neomysis* throughout the San Francisco Bay area but found it most abundant above San Pablo Bay, where the salinity was low. He stated that salinity was the most important factor limiting its distribution in that area. During the present study, *Neomysis* was collected in plankton samples from Suisun Bay to Rio Vista in the Sacramento River and at Station 5 in the San Joaquin River, and it was found in bass collected during April in Salmon Slough near Tracy.

The copepods *Diaptomus* sp. and *Cyclops* sp. are freshwater forms and *Eurytemora affinis* and *Pseudodiaptomus eurythalinus* are brackish-water forms (Light, 1954). In the summer we collected copepods at every tow-net station, but they were more abundant in the rivers above Pittsburg. *Pseudodiaptomus eurythalinus* was found in the Sacramento River below Pittsburg. *Eurytemora affinis* was collected from Station 26 to Station 11 on the Sacramento River and Station 8 on the San

Joaquin River. *Cyclops vernalis* and *Diaptomus novamexicanus* were found primarily above Pittsburg in both rivers. *Acartia clausii* was taken in a sample from Suisun Bay but was not identified in any bass stomachs. *Atthyella* and *Eucyclops agilis* were collected occasionally in plankton samples but were seldom found in bass stomachs.

Although we did not take tendipedid larvae in dredge or plankton samples, the California Department of Water Resources (1962b) found them commonly above Rio Vista in the Sacramento River. In a bass taken at Freeport there were *Tendipes*, *Cryptochironomus*, and *Limnochironomus*. These organisms were eaten by bass in areas where the water was essentially fresh.

The cladocerans, *Bosmina*, *Daphnia*, and *Diaphanosoma*, were identified in plankton samples taken primarily above Pittsburg in the Sacramento and San Joaquin rivers. The first two are classified as freshwater forms (Light, 1954).

DISCUSSION

In this study, several major groups comprising over 20 species of small animals were eaten by young-of-the-year striped bass. Many of these organisms were also reported in previous food habits studies. Similar organisms (freshwater shrimp, tendipedid larvae, *Mysis*, annelids, *Crago*, *Latona*, *Cyclops*, *Eurytemora*, and fish) have been found in small bass on the Atlantic Coast (Pearson, 1938; Merriman, 1941).

Tule fragments and other plant debris were found in bass stomachs and they have also been reported by other California investigators. It is not known whether bass eat them deliberately or accidentally.

This study's results were somewhat biased by the methods of analyzing the stomach contents. Frequency of occurrence is a better method than the numerical count for judging a food item's value, since it is a measure of general utilization by the population. However, neither of these methods takes the size of the food organism or its rate of digestion into consideration. Due to differences in organism size, the results underestimate the importance of *Neomysis* and *Corophium*. On the other hand, differences in digestion rates result in underestimating the importance of copepods, and to a lesser extent *Neomysis*, in relation to *Corophium*.

Also, stomach contents sometimes varied greatly between successive samplings at a single station (Figure 3). As a result, the exact importance of any one food organism is difficult to determine.

Evaluation of any bias resulting from the two methods of collecting, tow netting and seining, was impossible since they were employed in different seasons.

Although sampling problems made the development of forage ratios impractical, the occurrence of plankton species in the stomach generally agreed with the distribution of plankton in the environment. But, with the exception of *Corophium*, *Nereis*, and tendipedids, bass did not feed on available benthic fauna in most areas. The annelids, *Nereis succinea*, *N. lighti*, *Capitella capitella*, and *Polydora uncata*, reported by Felice (1958) as occurring in brackish or freshwater areas, are examples.

Since the distribution of estuarine organisms is generally controlled by salinity (Gunter, 1961), salinity largely determines bass diet in

most areas. This was exemplified by the relative importance of various copepod genera at stations of various salinities (Figure 2).

Water flow is also an important controlling factor and temperature, bottom type, and other ecological factors undoubtedly play significant roles. Differences in food eaten in Areas VIII and X in the fall resulted primarily from differences in water flow. Both areas are essentially fresh, but water movement in Area VIII was primarily tidal, while Area X was a lotic environment. In Area VIII, plankton (copecods and cladocerans) was the primary food, while in Area X plankton was presumably scarce, due to the one-way water flow, and bottom organisms (tendipedids) made up most of the diet.

Plankton blooms could account for the increase in copepod consumption in Areas VI and VII in the fall. Allen (1920) found copepods most abundant in the Stockton area in August and September, when the water was warm and stagnant.

Seasonal variations in the importance of *Corophium*, such as those in Areas VIII and IX, may have been related to its life cycle, of which little is known. This tube-dwelling organism is sometimes planktonic, since we have caught it in surface plankton samples. Some other amphipods are planktonic during their breeding season, so this might be the factor controlling *Corophium's* availability.

There were differences in stomach contents among different sizes of bass. Generally, as indicated by the summer food habits, larger bass fed on larger organisms. However, in the fall, bass fed less on *Neomysis* in all but Area III, while the frequency of occurrence of copepods was higher in Areas II, VI, and VII. Here again, seasonal variations in relative abundance and availability of a food organism could have caused this difference in bass food habits.

By comparing the distribution of young-of-the-year bass, as indicated by the spawning success surveys, and the food habits of these fish during the summer, the importance of *Neomysis* is clearly shown. Since *Neomysis* are considerably larger than copepods, their importance would be even greater on a weight basis. However, the importance of copepods and cladocerans to bass less than 1 inch long must not be overlooked. The availability of these organisms to newly-hatched bass may be a major factor affecting striped bass survival and abundance.

ACKNOWLEDGMENTS

Robert J. Toth planned the study. All three authors participated in the collection and analysis of stomachs. Final analysis and writing were done by William Heubach.

General supervision for the study was provided by Harold K. Chadwick and he, John B. Robinson, Arnold Albrecht, and Vincent Catania assisted in collecting samples.

Thomas E. Bowman, Smithsonian Institution, Washington, D.C., verified identification of the copepods and cladocerans. Milton Miller, University of California, Davis, examined the amphipods and isopods. Thomas Doyle, California Department of Fish and Game, identified the tendipedid larvae.

SUMMARY

Young-of-the-year striped bass inhabiting the Sacramento-San Joaquin Delta region fed primarily on *Neomysis*, copepods, cladocerans, *Corophium*, and tendipedid larvae.

In the summer, *Neomysis* was the most important food item of bass from Carquinez Strait to Rio Vista on the Sacramento River and Medford Island on the San Joaquin River, which is the general area inhabited by most of the young bass population. Above the mouth of the Mokelumne River, and in sloughs south of the San Joaquin River, copepods were the dominant food organism. *Neomysis* and *Corophium* were more important to bass over 1 inch long than to those under 1 inch, while copepods were less important to the larger fish. The consumption of cladocera was not related to size.

In the fall, copepods were more important, and *Neomysis* less important in the diet of bass from the San Joaquin River. Bass collected off the main channel of the San Joaquin and Sacramento rivers fed primarily on *Corophium*. Seasonal variations in abundance, or availability, of food organisms could account for these diet changes.

Tendipedid larvae and pupae were the principal food of bass collected in the rivers above the Delta, where there is less tidal movement and the water is fresh.

Fish were unimportant in the diet of young-of-the-year striped bass.

The occurrence of organisms in the stomachs generally agreed with the distribution of plankton organisms in the environment. Thus, food habits in any area were largely controlled by the factors controlling plankton distribution. Salinity and water flow were the most important of these factors.

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FISHES COLLECTED IN THE EASTERN PACIFIC DURING TUNA CRUISES, 1952 THROUGH 1959[1]

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INTRODUCTION

Marine biologists at the California State Fisheries Laboratory, Terminal Island, conducted extensive tropical tuna tagging and exploratory fishing operations during the 8 years from 1952 through 1959. Of 39 cruises totaling approximately 2,400 days, 12 were made aboard our research vessel *N. B. Scofield* and 27 aboard commercial live-bait tuna clippers. Our primary objective was to study Pacific Coast stocks of yellowfin tuna, *Thunnus albacares*, and skipjack tuna, *Katsuwonus pelamis*, harvested by California fishermen operating off Central and South America including the outlying banks and islands (Mais and Jow, 1960; Blunt and Messersmith, 1960).

These voyages also offered us an excellent opportunity to collect and study a wide assortment of marine organisms encountered on the tuna fishing and baiting grounds between California and Chile. Many of the species collected are noteworthy because they contribute a significant portion of the food required by our tuna stocks. All are useful, because they aid materially in understanding the habits and geographical distributions of relatively unfamiliar but important tropical species.

This paper deals only with fishes brought to our laboratory for identification and distribution and includes 86 families containing some 300 species in 209 genera. In addition it completes publication on all fish collections made during this series of cruises, supplementing those published previously (Clemens, 1955, 1957; Mais and Jow, 1960).

CAPTURE METHODS

The several methods used for collecting various fishes were: (H) hook and line—this includes all fish caught with rod and reel and by trolling; (N) bait net—sets of round-haul nets used by tuna fishermen for catching live bait were carefully observed for specimens; (L) night light—when vessels were drifting or at anchor during the evenings, a powerful light was suspended over the water. Fishes attracted were dipped with a small hand net; (S) stomach contents—most items came from yellowfin tuna and skipjack, but a few were taken from dolphinfish *(Coryphaena hippurus)*, pompano dolphinfish *(C. equisetis)*, and black skipjack *(Euthynnus lineatus)*; (M) miscellaneous—this category includes fish found on deck, near floating objects, and attached to

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other fishes—some specimens taken away from a pelican and a few donated by a Mexican diver also were included.

COLLECTING STATIONS

The magnitude of the area covered and density of sampling are shown by plotting the approximate location of the collecting stations (Figure 1).

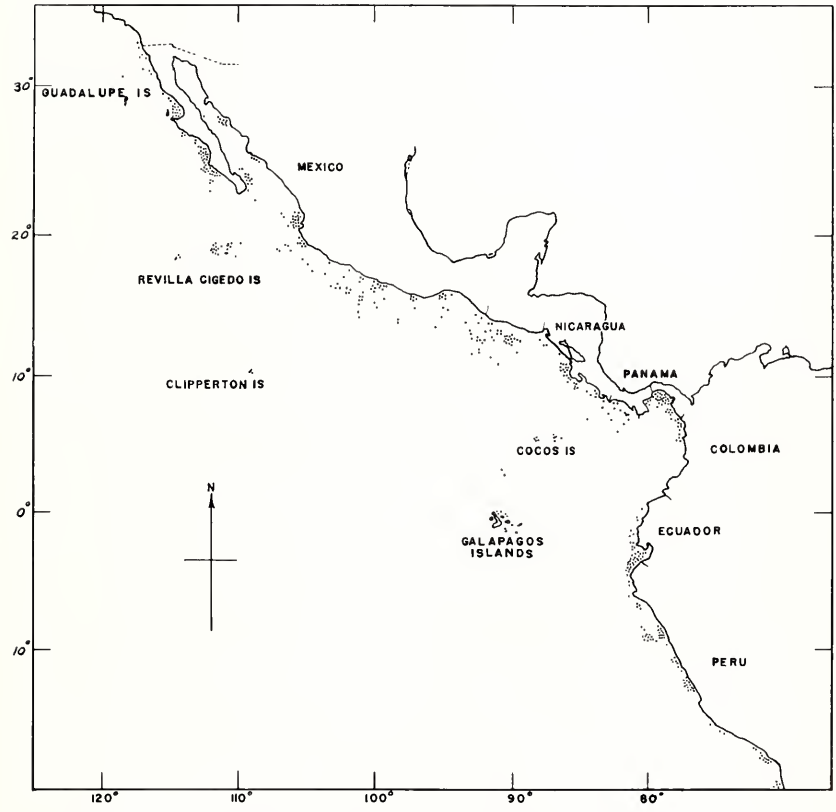

FIGURE 1. The area covered and approximate locations and density of collecting stations, February 1952 to May 1959.

To bring order to the large number of cruises and stations, the data were combined, arranged geographically from north to south by latitude and longitude, and assigned consecutive collection numbers from 1 to 472 (Table 1). In addition, the station numbers for each of the various cruises are given along with the cruise designation which includes the year it began, whether aboard a commercial vessel (C) or our research vessel *N. B. Scofield* (S), and the number of the cruise for that year. Thus, designation 57-C-4 means the cruise began in 1957 aboard a commercial vessel, and was the fourth commercial trip that year. The general location is the nearest land mass; for gulfs, an arbitrary point-to-point line was drawn to define the area within.

TABLE 1

Station Data for All Cruises, February 1952 to May 1959

Collection numbers	General location	Latitude	Longitude	Date mo. day year	Cruise	Station no.	Collection method*	Water temp.	Water depth
1	California	32° 44′ N.	117° 12′ W.	May 11, 1957	57-C-4	1	N		
2	Baja California	32° 22′ N.	117° 16′ W.	July 4, 1958	58-C-2	1	N	68.4° F.	7 fms.
3	Baja California	31° 34′ N.	117° 44′ W.	June 16, 1957	57-S-2	3	L		
4	Baja California	31° 22′ N.	116° 34′ W.	Aug. 21, 1958	58-C-3	1	N	64	13
5	Baja California	30° 48′ N.	116° 17′ W.	July 6, 1958	58-C-2	2	N	55	
6	Baja California	30° 47′ N.	116° 06′ W.	Sept. 5, 1958	58-C-2	22	N	64	
7	Baja California	30° 46′ N.	116° 14′ W.	Aug. 22, 1958	58-C-3	2	N	62.1	7
8	Baja California	30° 30′ N.	118° 56′ W.	June 17, 1957	57-S-2	4	L	64.4	
9	Baja California	29° 37′ N.	115° 28′ W.	Aug. 28, 1958	58-C-2	20	N	63.7	
10	Baja California	28° 58′ N.	114° 35′ W.	May 5, 1958	58-C-1	1	N	63.0	4
11	Baja California	28° 57′ N.	114° 30′ W.	May 6, 1958	58-C-1	2	N	62.4	4
12	Baja California	28° 07′ N.	120° 30′ W.	June 7, 1957	57-S-2	2	L	64.8	
13	Baja California	28° 07′ N.	115° 10′ W.	Feb. 26, 1955	55-S-1	55	L	58	14
14	Baja California	28° 05′ N.	115° 09′ W.	July 7, 1958	58-C-2	3	L	69	
15	Baja California	28° 05′ N.	115° 09′ W.	July 8, 1958	58-C-2	4	L–S	68	
16	Baja California	28° 05′ N.	115° 09′ W.	Aug. 30, 1958	58-C-2	21	H	71.6	
17	Gulf of California	27° 53′ N.	110° 53′ W.	May 9, 1957	57-C-3	1	N	75	2–6
18	Gulf of California	27° 53′ N.	110° 53′ W.	May 11, 1957	57-C-3	3	N	73.2	
19	Gulf of California	27° 51′ N.	110° 53′ W.	Mar. 13, 1956	56-C-1	3	M		
20	Gulf of California	27° 51′ N.	110° 51′ W.	May 10, 1957	57-C-3	2	L	73.2	13
21	Gulf of California	27° 50′ N.	110° 55′ W.	May 20, 1956	56-C-2	1	N		
22	Gulf of California	27° 42′ N.	110° 42′ W.	Mar. 14, 1956	56-C-1	4	N		
23	Gulf of California	27° 42′ N.	110° 40′ W.	Mar. 12, 1956	56-C-1	2	N		
24	Baja California	27° 41′ N.	114° 53′ W.	July 22, 1956	56-C-4	1	N		
25	Baja California	27° 41′ N.	114° 52′ W.	Aug. 3, 1956	56-C-4	8	N		
26	Baja California	27° 36′ N.	121° 04′ W.	June 5, 1957	57-S-2	1	L	64	1,000+
27	Gulf of California	27° 35′ N.	110° 40′ W.	May 17, 1957	57-C-4	2	N	73	
28	Gulf of California	27° 20′ N.	110° 40′ W.	May 18, 1957	57-C-4	3	N		
29	Baja California	27° 10′ N.	115° 07′ W.	July 10, 1958	58-C-2	6	L	70	
30	Baja California	27° 08′ N.	114° 17′ W.	Aug. 9, 1958	58-C-2	13	N		
31	Baja California	27° 08′ N.	114° 10′ W.	July 23, 1958	58-C-2	8	N	68.9	
32	Baja California	27° 07′ N.	114° 53′ W.	July 29, 1958	58-C-2	10	H		
33	Baja California	27° 07′ N.	114° 25′ W.	July 28, 1958	58-C-2	9	N	64.4	
34	Baja California	27° 07′ N.	114° 15′ W.	Aug. 14, 1958	58-C-2	15	N	70.2	
35	Baja California	27° 06′ N.	114° 55′ W.	Aug. 16, 1958	58-C-2	16	N	68	

36	Baja California	27° 05′ N.	114° 15′ W.	July 16, 1958	58-C-2	7	N	65 67	
37	Baja California	27° 03′ N.	114° 50′ W.	Aug. 23, 1958	58-C-2	19	N	68.9	
38	Baja California	26° 48′ N.	113° 25′ W.	July 3, 1958	58-C-1	21	N	68	5
39	Baja California	26° 46′ N.	111° 28′ W.	Aug. 9, 1958	58-C-2	14	S	75.5	
40	Baja California	26° 38′ N.	113° 26′ W.	Jan. 8, 1955	55-S-1	2	H	63	2–11
41	Baja California	26° 34′ N.	114° 27′ W.	July 31, 1958	58-C-2	11	S	70.2	
42	Baja California	26° 31′ N.	113° 17′ W.	Aug. 10, 1956	56-C-4	11	N		
43	Baja California	26° 30′ N.	111° 52′ W.	Feb. 18, 1952	52-S-2	1	M		
44	Baja California	26° 02′ N.	113° 36′ W.	Aug. 19, 1958	58-C-2	18	L	75	10
45	Baja California	25° 44′ N.	113° 07′ W.	Aug. 2, 1958	58-C-2	12	N	78.8	
46	Baja California	25° 36′ N.	113° 24′ W.	Jan. 5, 1955	55-S-1	1	M		
47	Gulf of California	25° 20′ N.	109° 00′ W.	Jan. 27, 1957	57-C-2	1	N	66	9
48	Gulf of California	25° 20′ N.	109° 00′ W.	Jan. 29, 1957	57-C-2	2	N	66	20
49	Gulf of California	25° 16′ N.	108° 30′ W.	April 30, 1956	56-C-1	38	H–N	66	10
50	Gulf of California	25° 15′ N.	108° 30′ W.	Mar. 10, 1956	56-C-1	1	N	63	5
51	Baja California	24° 46′ N.	112° 15′ W.	July 25, 1956	56-C-3	12	H		
52	Baja California	24° 45′ N.	112° 15′ W.	July 24, 1956	56-C-3	11	L		
53	Baja California	24° 45′ N.	112° 15′ W.	July 27, 1956	56-C-3	13	L		
54	Baja California	24° 44′ N.	112° 12′ W.	Sept. 5, 1954	54-C-3	1	N		
55	Baja California	24° 43′ N.	112° 14′ W.	July 10, 1956	56-C-3	2	N	68.2	19
56	Baja California	24° 42′ N.	112° 12′ W.	June 16, 1958	58-C-1	19	N	66.2	10.5
57	Baja California	24° 40′ N.	112° 08′ W.	Jan. 10, 1955	55-S-1	5	H	66.5	2
58	Baja California	24° 39′ N.	112° 08′ W.	July 22, 1956	56-C-3	10	N	75.6	13
59	Baja California	24° 39′ N.	112° 08′ W.	July 28, 1956	56-C-3	15	L		
60	Baja California	24° 39′ N.	112° 05′ W.	July 14, 1956	56-C-3	6	N	70.7	8
61	Baja California	24° 39′ N.	112° 05′ W.	July 15, 1956	56-C-3	7	N	71.8	8
62	Baja California	24° 38′ N.	112° 08′ W.	May 25, 1958	58-C-1	13	N	66.4	10
63	Baja California	24° 38′ N.	112° 08′ W.	May 26, 1958	58-C-1	14	N	66.4	10
64	Baja California	24° 36′ N.	112° 02′ W.	July 30, 1956	56-C-3	16	L–N		
65	Baja California	24° 35′ N.	112° 04′ W.	Sept. 15, 1955	55-C-4	1	N	78	
66	Baja California	24° 28′ N.	112° 05′ W.	Sept. 15, 1955	55-C-4	2	H		
67	Baja California	24° 22′ N.	111° 33′ W.	Feb. 19, 1952	52-S-2	2	L		
68	Baja California	24° 22′ N.	111° 29′ W.	Jan. 9, 1955	55-S-1	3	L	65	5
69	Baja California	24° 22′ N.	111° 29′ W.	Jan. 10, 1955	55-S-1	4	L	66	14
70	Baja California	24° 22′ N.	111° 29′ W.	Jan. 11, 1955	55-S-1	6	H	65.5	14
71	Baja California	24° 21′ N.	111° 30′ W.	May 30, 1958	58-C-1	16	N	73.2	9
72	Baja California	24° 21′ N.	111° 30′ W.	June 2, 1958	58-C-1	17	N	67.8	9
73	Baja California	24° 21′ N.	111° 30′ W.	June 3, 1958	58-C-1	18	N	65.1	12
74	Baja California	24° 21′ N.	111° 29′ W.	May 29, 1958	58-C-1	15	N	67.8	18
75	Baja California	24° 20′ N.	111° 29′ W.	May 22, 1958	58-C-1	12	L	66.7	18
76	Baja California	24° 20′ N.	111° 28′ W.	May 21, 1958	58-C-1	11	N	66.7	18
77	Gulf of California	24° 19′ N.	109° 55′ W.	Jan. 14, 1957	57-C-1	5	N	67.3	2
78	Gulf of California	24° 13′ N.	110° 05′ W.	Jan. 14, 1957	57-C-1	4	H	69.1	5

TABLE 1—Continued

Station Data for All Cruises, February 1952 to May 1959

Collection numbers	General location	Latitude	Longitude	Date mo. day year	Cruise	Station no.	Collection method*	Water temp.	Water depth
79	Baja California	24° 10′ N.	111° 40′ W.	Mar. 7, 1959	59-C-1	1	N		
80	Baja California	24° 10′ N.	111° 40′ W.	Mar. 8, 1959	59-C-1	2	N		
81	Baja California	24° 10′ N.	111° 40′ W.	Mar. 9, 1959	59-C-1	3	N	69	
82	Baja California	24° 10′ N.	111° 40′ W.	Mar. 10, 1959	59-C-1	4	N	69	
83	Baja California	24° 07′ N.	111° 52′ W.	July 27, 1956	56-C-3	14	H		
84	Gulf of California	23° 59′ N.	109° 49′ W.	Jan. 13, 1957	57-C-1	2	N	69.1	1
85	Gulf of California	23° 50′ N.	109° 43′ W.	Jan. 15, 1957	57-C-1	7	N	68.2	1
86	Gulf of California	23° 50′ N.	109° 42′ W.	Jan. 14, 1957	57-C-1	6	H	67.3	5
87	Gulf of California	23° 47′ N.	109° 43′ W.	Jan. 13, 1957	57-C-1	1	N	69.1	1
88	Gulf of California	23° 43′ N.	109° 42′ W.	Jan. 14, 1957	57-C-1	3	N	67.3	1
89	Gulf of California	23° 43′ N.	109° 42′ W.	Jan. 18, 1957	57-C-1	9	N	67.5	1
90	Gulf of California	23° 43′ N.	109° 42′ W.	Jan. 19, 1957	57-C-1	10	N	67.6	5
91	Gulf of California	23° 43′ N.	109° 42′ W.	Jan. 20, 1957	57-C-1	11	N	69.1	1
92	Gulf of California	23° 40′ N.	109° 41′ W.	Jan. 16, 1957	57-C-1	8	N	68.2	1
93	Baja California	23° 35′ N.	112° 12′ W.	July 13, 1956	56-C-3	5	H	77.4	1,580
94	Baja California	23° 35′ N.	112° 11′ W.	July 11, 1956	56-C-3	3	L		
95	Baja California	23° 20′ N.	112° 27′ W.	July 12, 1956	56-C-3	4	L		
96	Gulf of California	23° 01′ N.	109° 42′ W.	May 18, 1956	56-C-1	47	N	74	
97	Baja California	22° 47′ N.	112° 14′ W.	July 17, 1956	56-C-3	8	L		
98	Baja California	22° 10′ N.	109° 00′ W.	July 27, 1957	57-C-3	37	M	80.2	1,500+
99	Mexico	21° 31′ N.	105° 21′ W.	June 30, 1957	57-C-4	11	N		
100	Mexico	21° 25′ N.	106° 23′ W.	June 2, 1956	56-C-2	6	L		
101	Mexico	21° 23′ N.	107° 08′ W.	Feb. 22, 1952	52-S-2	3	S		
102	Mexico	21° 15′ N.	106° 15′ W.	May 28, 1956	56-C-2	5	L		
103	Mexico	21° 15′ N.	106° 15′ W.	June 5, 1956	56-C-2	7	L		
104	Mexico	21° 15′ N.	106° 15′ W.	June 7, 1956	56-C-2	10	L		
105	Mexico	21° 15′ N.	106° 15′ W.	June 11, 1956	56-C-2	11	L		
106	Mexico	21° 15′ N.	106° 15′ W.	June 12, 1956	56-C-2	12	L		
107	Mexico	21° 05′ N.	106° 40′ W.	July 5, 1957	57-C-4	12	L		
108	Mexico	21° 01′ N.	106° 14′ W.	Jan. 21, 1957	57-C-1	12	L	77.5	
109	Mexico	21° 00′ N.	106° 00′ W.	June 25, 1957	57-C-4	10	L		
110	Mexico	20° 43′ N.	105° 23′ W.	April 7, 1956	56-C-1	24	N	72	14
111	Mexico	20° 41′ N.	105° 35′ W.	Mar. 19, 1956	56-C-1	7	N	70	35
112	Mexico	20° 41′ N.	105° 31′ W.	Mar. 18, 1956	56-C-1	6	N	70	4
113	Mexico	20° 38′ N.	105° 19′ W.	April 6, 1956	56-C-1	23	N–H	72	7

114	Mexico	20° 32′ N.	105° 17′ W.	Mar. 18, 1956	56-C-1	5	N	70	4
115	Mexico	20° 30′ N.	105° 30′ W.	May 27, 1956	56-C-2	4	N		
116	Mexico	20° 30′ N.	105° 30′ W.	June 6, 1956	56-C-2	8	N		
117	Mexico	20° 30′ N.	105° 30′ W.	June 7, 1956	56-C-2	9	N		
118	Mexico	20° 25′ N.	105° 42′ W.	June 23, 1957	57-C-4	8	L		
119	Mexico	20° 24′ N.	106° 32′ W.	Feb. 23, 1952	52-S-2	4	S		
120	Mexico	19° 40′ N.	105° 24′ W.	Jan. 14, 1955	55-S-1	7	S	77	283
121	Mexico	19° 33′ N.	105° 08′ W.	Feb. 24, 1952	52-S-2	5	L–H		
122	Mexico	19° 23′ N.	105° 15′ W.	Feb. 26, 1952	52-S-2	6	L		
123	Mexico	19° 20′ N.	105° 55′ W.	Mar. 7, 1952	52-S-2	9	S		
124	Mexico	19° 19′ N.	105° 08′ W.	Nov. 17, 1957	57-C-6	1	S	85	300
125	Revilla Gigedo Is.	19° 18′ N.	110° 49′ W.	April 27, 1957	56-C-1	37	L–H	73	1,000+
126	Revilla Gigedo Is.	19° 15′ N.	110° 05′ W.	Aug. 7, 1956	56-C-4	10	L		
127	Revilla Gigedo Is.	19° 15′ N.	110° 00′ W.	Aug. 6, 1956	56-C-4	9	L		
128	Mexico	19° 07′ N.	105° 23′ W.	May 24, 1956	56-C-2	3	L		
129	Revilla Gigedo Is.	19° 05′ N.	111° 38′ W.	July 26, 1956	56-C-4	2	L		
130	Mexico	19° 05′ N.	106° 50′ W.	April 11, 1956	56-C-1	28	L	76	1,900
131	Mexico	19° 03′ N.	106° 40′ W.	April 12, 1956	56-C-1	29	L	77	1,946
132	Revilla Gigedo Is.	19° 02′ N.	112° 08′ W.	July 19, 1956	56-C-3	9	L		
133	Mexico	19° 01′ N.	105° 18′ W.	May 23, 1956	56-C-2	2	L		
134	Revilla Gigedo Is.	19° 00′ N.	112° 09′ W.	May 11, 1958	58-C-1	5	L	79.5	50
135	Revilla Gigedo Is.	19° 00′ N.	112° 09′ W.	May 12, 1958	58-C-1	6	H	80	50
136	Revilla Gigedo Is.	19° 00′ N.	112° 09′ W.	May 15, 1958	58-C-1	8	H–M	79.7	50
137	Revilla Gigedo Is.	18° 59′ N.	112° 02′ W.	July 27, 1956	56-C-4	3	L		
138	Revilla Gigedo Is.	18° 56′ N.	112° 03′ W.	July 28, 1956	56-C-4	4	L		
139	Revilla Gigedo Is.	18° 55′ N.	112° 03′ W.	July 29, 1956	56-C-4	5	L		
140	Revilla Gigedo Is.	18° 55′ N.	112° 05′ W.	Aug. 1, 1956	56-C-4	7	L		
141	Revilla Gigedo Is.	18° 52′ N.	110° 57′ W.	May 13, 1958	58-C-1	7	L	79.7	38
142	Mexico	18° 50′ N.	107° 21′ W.	April 8, 1956	56-C-1	25	L	74	1,780
143	Mexico	18° 50′ N.	107° 21′ W.	April 9, 1956	56-C-1	26	M–H	76	1,878
144	Mexico	18° 46′ N.	106° 20′ W.	April 11, 1956	56-C-1	27	S	76	1,899
145	Revilla Gigedo Is.	18° 39′ N.	111° 46′ W.	July 30, 1956	56-C-4	6	L		
146	Revilla Gigedo Is.	18° 21′ N.	114° 42′ W.	May 17, 1958	58-C-1	9	L	76.5	52
147	Revilla Gigedo Is.	18° 21′ N.	114° 42′ W.	May 18, 1958	58-C-1	10	H–L	76.6	10
148	Mexico	18° 15′ N.	103° 30′ W.	May 22, 1957	57-C-4	4	L	81	
149	Revilla Gigedo Is.	18° 11′ N.	110° 37′ W.	April 27, 1956	56-C-1	36	S	73	1,781
150	Mexico	18° 10′ N.	105° 23′ W.	Mar. 20, 1956	56-C-1	8	H	78.5	1,000+
151	Mexico	17° 55′ N.	105° 09′ W.	Mar. 20, 1956	56-C-1	9	S	77	1,000+
152	Mexico	17° 35′ N.	104° 50′ W.	Mar. 20, 1956	56-C-1	10	M	77	1,000+
153	Mexico	17° 29′ N.	102° 02′ W.	Feb. 21, 1955	55-S-1	54	S	79	1,000+
154	Mexico	17° 12′ N.	103° 52′ W.	May 3, 1956	56-C-1	39	L	80	1,640
155	Mexico	17° 12′ N.	101° 10′ W.	June 15, 1957	57-C-4	6	L	85	
156	Mexico	17° 12′ N.	101° 10′ W.	June 16, 1957	57-C-4	7	L	85	

TABLE 1—Continued

Station Data for All Cruises, February 1952 to May 1959

Collection numbers	General location	Latitude	Longitude	Date mo. day year	Cruise	Station no.	Collection method*	Water temp.	Water depth
157	Mexico	17° 00′ N.	102° 30′ W.	April 3, 1956	56-C-1	22	L	80	1,937
158	Mexico	16° 52′ N.	100° 22′ W.	Feb. 20, 1955	55-S-1	53	L	79	450
159	Mexico	16° 51′ N.	99° 56′ W.	May 8, 1956	56-C-1	42	L–H	80	8
160	Mexico	16° 50′ N.	99° 56′ W.	May 11, 1956	56-C-1	45	L–M	81	8
161	Mexico	16° 50′ N.	99° 55′ W.	Mar. 4, 1952	52-S-2	8	L		
162	Mexico	16° 48′ N.	99° 52′ W.	May 12, 1956	56-C-1	46	L–H	81	13
163	Mexico	16° 40′ N.	101° 10′ W.	May 10, 1956	56-C-1	44	S	83	2,445
164	Mexico	16° 30′ N.	99° 31′ W.	Jan. 16, 1955	55-S-1	8	S		
165	Mexico	16° 25′ N.	103° 00′ W.	Mar. 21, 1956	56-C-1	11	S	80	1,000+
166	Mexico	16° 23′ N.	99° 28′ W.	Feb. 29, 1952	52-S-2	7	L		
167	Mexico	16° 21′ N.	103° 33′ W.	April 14, 1956	56-C-1	30	S	77	1,805
168	Mexico	16° 16′ N.	100° 19′ W.	May 9, 1956	56-C-1	43	L	80	34
169	Mexico	16° 10′ N.	103° 07′ W.	May 5, 1956	56-C-1	40	H	82	1,727
170	Mexico	16° 10′ N.	95° 11′ W.	Nov. 17, 1958	58-C-3	42	N	82.6	6
171	Mexico	16° 05′ N.	102° 55′ W.	April 2, 1956	56-C-1	21	L	79	1,727
172	Mexico	16° 04′ N.	95° 23′ W.	Mar. 15, 1959	59-C-1	7	L	82	
173	Mexico	16° 04′ N.	95° 22′ W.	Mar. 12, 1957	57-C-2	24	N	78	18
174	Mexico	16° 03′ N.	102° 15′ W.	Mar. 30, 1956	56-C-1	19	S	80	1,727
175	Mexico	16° 03′ N.	100° 32′ W.	Jan. 24, 1957	57-C-1	13	L	82.6	
176	Mexico	16° 03′ N.	100° 23′ W.	Mar. 14, 1957	57-C-2	26	L	80	
177	Mexico	16° 02′ N.	95° 22′ W.	Mar. 30, 1957	57-C-1	38	L–N	74.5	8
178	Mexico	16° 00′ N.	102° 20′ W.	Mar. 29, 1956	56-C-1	18	L–S	80	1,920
179	Mexico	16° 00′ N.	100° 30′ W.	Mar. 13, 1957	57-C-2	25	L	79	
180	Mexico	16° 00′ N.	95° 20′ W.	Mar. 3, 1957	57-C-2	20	L–N	78	18
181	Mexico	16° 00′ N.	95° 20′ W.	Mar. 4, 1957	57-C-2	21	L–N	78	18
182	Mexico	15° 58′ N.	102° 05′ W.	Mar. 30, 1956	56-C-1	20	L	80	1,720
183	Mexico	15° 56′ N.	97° 30′ W.	Mar. 25, 1956	56-C-1	16	H	84	20
184	Mexico	15° 56′ N.	97° 30′ W.	Mar. 24, 1956	56-C-1	15	L	84	1,600
185	Mexico	15° 51′ N.	101° 52′ W.	May 6, 1956	56-C-1	41	S	86	1,720
186	Mexico	15° 45′ N.	101° 04′ W.	April 19, 1956	56-C-1	34	L	82	2,037
187	Mexico	15° 40′ N.	97° 31′ W.	Feb. 3, 1958	57-C-5	34	S	81	
188	Mexico	15° 40′ N.	94° 35′ W.	Mar. 15, 1959	59-C-1	6	S		
189	Mexico	15° 35′ N.	101° 20′ W.	April 18, 1956	56-C-1	33	S–M	83	2,050
190	Mexico	15° 32′ N.	101° 05′ W.	April 17, 1956	56-C-1	32	S	82	2,018
191	Mexico	15° 30′ N.	101° 03′ W.	Mar. 21, 1956	56-C-1	12	L	80	1,000+

192	Mexico	15° 30′ N.	97° 05′ W.	Mar. 8, 1958	57-C-6	60	S	82.2	1,360
193	Mexico	15° 25′ N.	99° 29′ W.	Jan. 26, 1957	57-C-1	14	L	83.3	
194	Mexico	15° 24′ N.	101° 17′ W.	Mar. 26, 1956	56-C-1	17	L	84	2,370
195	Mexico	15° 24′ N.	97° 20′ W.	Mar. 23, 1956	56-C-1	14	L	83	1,150
196	Mexico	15° 14′ N.	100° 11′ W.	Mar. 22, 1956	56-C-1	13	S	83	1,800
197	Mexico	15° 10′ N.	106° 26′ W.	Feb. 1, 1954	54-C-1	1	M		
198	Mexico	15° 00′ N.	101° 35′ W.	April 21, 1956	56-C-1	35	S	83	
199	Mexico	14° 56′ N.	100° 00′ W.	April 16, 1956	56-C-1	31	L	84	1,863
200	Mexico	14° 55′ N.	95° 03′ W.	May 19, 1957	57-C-3	5	L	86.5	2,650
201	Mexico	14° 49′ N.	94° 53′ W.	May 18, 1957	57-C-3	4	L	87.4	2,640
202	Mexico	14° 45′ N.	97° 10′ W.	June 10, 1957	57-C-4	5	H	85	
203	Mexico	14° 38′ N.	101° 42′ W.	Feb. 5, 1957	57-C-2	3	L	82	
204	Mexico	14° 24′ N.	92° 55′ W.	Jan. 18, 1955	55-S-1	9	S	83	300
205	Guatemala	14° 12′ N.	92° 26′ W.	Jan. 18, 1955	55-S-1	10	S	84	50
206	Mexico	14° 12′ N.	101° 25′ W.	Feb. 6, 1957	57-C-2	4	L	83.5	
207	Mexico	14° 10′ N.	95° 15′ W.	May 20, 1957	57-C-3	6	L	85.8	2,320
208	Mexico	14° 01′ N.	98° 27′ W.	Feb. 7, 1957	57-C-2	5	S	83.5	
209	Mexico	13° 59′ N.	98° 28′ W.	Feb. 8, 1957	57-C-2	6	S	82	
210	Mexico	13° 58′ N.	93° 39′ W.	May 21, 1957	57-C-3	7	L	86.7	3,500+
211	Guatemala	13° 50′ N.	92° 30′ W.	Feb. 1, 1958	57-C-5	33	S	80	
212	Guatemala	13° 48′ N.	91° 53′ W.	Nov. 21, 1957	57-C-6	2	S		60
213	Guatemala	13° 43′ N.	91° 50′ W.	Feb. 18, 1955	55-S-1	52	S	81	100
214	Mexico	13° 36′ N.	95° 42′ W.	April 5, 1953	53-C-1	1	L		
215	Guatemala	13° 27′ N.	91° 44′ W.	Mar. 6, 1958	57-C-6	59	M–S	82.8	1,306
216	Guatemala	13° 20′ N.	90° 57′ W.	Feb. 22, 1957	57-C-2	15	S–L	82–81	
217	Guatemala	13° 11′ N.	92° 02′ W.	Mar. 18, 1959	59-C-1	8	S		
218	Guatemala	13° 08′ N.	90° 55′ W.	Mar. 21, 1957	57-C-1	32	L	84	
219	Guatemala	13° 07′ N.	91° 01′ W.	Mar. 19, 1957	57-C-1	31	L	84	
220	Guatemala	13° 05′ N.	93° 05′ W.	Mar. 1, 1957	57-C-2	19	S	80	
221	El Salvador	13° 04′ N.	89° 51′ W.	April 7, 1957	57-C-1	40	L	83.8	
222	Guatemala	13° 02′ N.	93° 06′ W.	Feb. 16, 1957	57-C-2	8	M	80	
223	El Salvador	12° 58′ N.	90° 14′ W.	Mar. 8, 1957	57-C-2	23	L	80	85
224	El Salvador	12° 58′ N.	90° 12′ W.	Mar. 7, 1957	57-C-2	22	S	80	
225	El Salvador	12° 57′ N.	90° 32′ W.	Feb. 17, 1955	55-S-1	51	L	81	1,000+
226	El Salvador	12° 47′ N.	90° 27′ W.	Mar. 25, 1957	57-C-1	36	L	83.5	
227	Guatemala	12° 45′ N.	90° 45′ W.	Mar. 23, 1957	57-C-1	34	M	83.8	
228	Guatemala	12° 43′ N.	92° 42′ W.	Feb. 28, 1957	57-C-2	18	L	82	
229	El Salvador	12° 43′ N.	90° 14′ W.	Mar. 22, 1957	57-C-1	33	L	83.3	
230	Guatemala	12° 42′ N.	91° 35′ W.	April 3, 1957	57-C-1	39	L	85.5	
231	El Salvador	12° 39′ N.	90° 04′ W.	Jan. 19, 1955	55-S-1	12	S	82	1,000+
232	El Salvador	12° 38′ N.	90° 21′ W.	Mar. 23, 1957	57-C-1	35	N	84	
233	Guatemala	12° 37′ N.	91° 14′ W.	Feb. 21, 1957	57-C-2	14	L	80	
234	El Salvador	12° 35′ N.	89° 55′ W.	Jan. 19, 1955	55-S-1	14	S	80	1,000+

TABLE 1—Continued

Station Data for All Cruises, February 1952 to May 1959

Collection numbers	General location	Latitude	Longitude	Date mo. day year	Cruise	Station no.	Collection method*	Water temp.	Water depth
235	El Salvador	12° 35′ N.	89° 49′ W.	Jan. 19, 1955	55-S-1	13	M–L	80	1,000+
236	El Salvador	12° 32′ N.	90° 20′ W.	Mar. 18, 1957	57-C-1	29	L	84.4	
237	Guatemala	12° 30′ N.	92° 08′ W.	Feb. 27, 1957	57-C-2	17	L	80	
238	Guatemala	12° 29′ N.	92° 22′ W.	Feb. 25, 1957	57-C-2	16	L	80	
239	Guatemala	12° 27′ N.	92° 15′ W.	Feb. 18, 1957	57-C-2	10	S	80	
240	El Salvador	12° 27′ N.	90° 14′ W.	Jan. 19, 1955	55-S-1	11	S	82	1,000+
241	Nicaragua	12° 26′ N.	88° 04′ W.	Mar. 19, 1959	59-C-1	9	S	82.1	
242	Guatemala	12° 25′ N.	93° 02′ W.	Feb. 12, 1957	57-C-2	7	M	80	
243	El Salvador	12° 25′ N.	90° 42′ W.	April 14, 1957	57-C-1	42	L	83.7	
244	El Salvador	12° 25′ N.	89° 36′ W.	April 11, 1957	57-C-1	41	L	83.7	
245	Guatemala	12° 20′ N.	92° 29′ W.	Feb. 19, 1957	57-C-2	11	S–M	80	
246	Nicaragua	12° 10′ N.	87° 30′ W.	Sept. 21, 1954	54-C-3	4	L		
247	Nicaragua	12° 09′ N.	87° 57′ W.	May 26, 1957	57-C-3	10	L	85.2	120
248	El Salvador	12° 07′ N.	90° 39′ W.	Mar. 27, 1957	57-C-1	37	N	83.7	
249	Guatemala	11° 51′ N.	92° 36′ W.	Feb. 20, 1957	57-C-2	13	L	80	
250	Guatemala	11° 47′ N.	92° 32′ W.	Feb. 20, 1957	57-C-2	12	M	80	
251	El Salvador	11° 37′ N.	89° 50′ W.	Feb. 7, 1954	54-C-1	2	N		
252	Nicaragua	11° 32′ N.	86° 40′ W.	July 20, 1957	57-C-3	36	M	84	100+
253	Guatemala	11° 30′ N.	93° 00′ W.	Feb. 17, 1957	57-C-2	9	M	80	
254	Guatemala	11° 13′ N.	91° 41′ W.	May 24, 1957	57-C-3	8	L	85	2,140
255	Costa Rica	10° 56′ N.	86° 44′ W.	Jan. 29, 1958	57-C-5	30–31	S–L	80	
256	Costa Rica	10° 56′ N.	86° 44′ W.	Jan. 30, 1958	57-C-5	32	S	80	
257	Costa Rica	10° 56′ N.	86° 31′ W.	Jan. 21, 1955	55-S-1	16	S	76	112
258	El Salvador	10° 50′ N.	91° 00′ W.	May 24, 1957	57-C-3	9	L	85.2	2,000+
259	Nicaragua	10° 49′ N.	86° 37′ W.	Jan. 27, 1958	57-C-5	28	S	81	
260	Costa Rica	10° 47′ N.	86° 15′ W.	Oct. 6, 1954	54-C-3	8	L		
261	Costa Rica	10° 35′ N.	85° 58′ W.	Jan. 22, 1955	55-S-1	18	S	81	1,000+
262	Costa Rica	10° 31′ N.	86° 12′ W.	Mar. 27, 1954	54-C-1	9	L		
263	Costa Rica	10° 30′ N.	86° 05′ W.	Jan. 21, 1955	55-S-1	15	L	76.5	60
264	Costa Rica	10° 28′ N.	86° 18′ W.	Jan. 26, 1958	57-C-5	26–27	S–L	81	
265	Costa Rica	10° 25′ N.	86° 13′ W.	May 28, 1957	57-C-3	11	L	84.6	110
266	Costa Rica	10° 22′ N.	85° 57′ W.	Sept. 18, 1954	54-C-3	3	L		
267	Clipperton Is.	10° 18′ N.	109° 14′ W.	Jan. 29, 1957	57-C-1	15	L	79.9	85
268	Costa Rica	10° 09′ N.	86° 09′ W.	Mar. 3, 1958	57-C-6	58	L	84.6	530
269	Costa Rica	10° 01′ N.	85° 55′ W.	July 17, 1957	57-C-3	35	L	84	560

270	Costa Rica	09° 46′ N.	85° 48′ W.	May 30, 1957	57-C-3	12	L	85.6	140
271	Costa Rica	09° 34′ N.	86° 02′ W.	Mar. 3, 1958	57-C-6	57	S	84.9	1,795
272	Costa Rica	09° 34′ N.	85° 30′ W.	Nov. 14, 1958	58-C-3	41	S	82.2	
273	Costa Rica	09° 30′ N.	85° 26′ W.	Feb. 15, 1955	55-S-1	50	S–L	84.5	500
274	Costa Rica	09° 13′ N.	85° 30′ W.	Mar. 3, 1958	57-C-6	56	S	84.7	930
275	Costa Rica	09° 08′ N.	83° 45′ W.	Feb. 14, 1955	55-S-1	49	L	86	11
276	Costa Rica	09° 02′ N.	85° 35′ W.	Jan. 22, 1955	55-S-1	17	L	81	1,000+
277	Costa Rica	09° 02′ N.	85° 04′ W.	Jan. 23, 1955	55-S-1	20	S		1,000+
278	Costa Rica	08° 58′ N.	81° 56′ W.	Mar. 14, 1957	57-C-1	28	L	84.6	3
279	Gulf of Panama	08° 57′ N.	79° 33′ W.	Feb. 22, 1958	57-C-6	52	H	75	6–7
280	Gulf of Panama	08° 57′ N.	79° 33′ W.	Feb. 23, 1958	57-C-6	53–54	H–L	74.3	8–17
281	Gulf of Panama	08° 56′ N.	79° 33′ W.	Feb. 1, 1955	55-S-1	31	L		
282	Costa Rica	08° 54′ N.	83° 52′ W.	Feb. 14, 1955	55-S-1	48	S	85	40
283	Gulf of Panama	08° 53′ N.	79° 07′ W.	Feb. 16, 1957	57-C-1	19	N–L	69.3	9
284	Gulf of Panama	08° 48′ N.	79° 33′ W.	Feb. 12, 1958	57-C-6	47	L	79	8
285	Gulf of Panama	08° 44′ N.	79° 13′ W.	Mar. 8, 1957	57-C-1	25	N	75.9	26
286	Costa Rica	08° 43′ N.	84° 18′ W.	Jan. 23, 1955	55-S-1	19	L	83	200
287	Gulf of Panama	08° 42′ N.	79° 19′ W.	June 13, 1957	57-C-3	22	L	82	
288	Gulf of Panama	08° 42′ N.	78° 43′ W.	Mar. 8, 1957	57-C-1	26	N	80.6	2
289	Gulf of Panama	08° 41′ N.	79° 04′ W.	Mar. 5, 1957	57-C-1	24	N	76.8	12
290	Gulf of Panama	08° 37′ N.	78° 38′ W.	Feb. 28, 1958	57-C-6	55	N	82.8	7
291	Gulf of Panama	08° 36′ N.	79° 36′ W.	Feb. 5, 1955	55-S-1	35	L	80	9
292	Gulf of Panama	08° 36′ N.	79° 36′ W.	Feb. 6, 1955	55-S-1	38	H	80	3
293	Costa Rica	08° 35′ N.	83° 50′ W.	Oct. 31, 1954	54-C-3	11	L		
294	Gulf of Panama	08° 34′ N.	79° 46′ W.	Mar. 10, 1957	57-C-1	27	N	77	3
295	Gulf of Panama	08° 31′ N.	78° 56′ W.	Feb. 4, 1955	55-S-1	34	L	80	9
296	Gulf of Panama	08° 30′ N.	79° 31′ W.	Jan. 22, 1958	57-C-5	25	N	80	
297	Gulf of Panama	08° 30′ N.	78° 31′ W.	Feb. 16, 1958	57-C-6	48-49-50	N–L	77–78	2–7
298	Gulf of Panama	08° 27′ N.	79° 02′ W.	Feb. 5, 1955	55-S-1	36	S	81	
299	Gulf of Panama	08° 18′ N.	80° 16′ W.	June 15, 1957	57-C-3	23	N	84	1–2
300	Gulf of Panama	08° 18′ N.	80° 16′ W.	June 18, 1957	57-C-3	24	N	83	1–2
301	Gulf of Panama	08° 18′ N.	80° 16′ W.	June 25, 1957	57-C-3	30	N	83.8	1–2
302	Gulf of Panama	08° 18′ N.	80° 16′ W.	July 10, 1957	57-C-3	34	H	83.8	5–7
303	Panama	08° 15′ N.	82° 47′ W.	Jan. 27, 1955	55-S-1	24	S–L–H	83	14
304	Panama	08° 15′ N.	82° 47′ W.	Jan. 28, 1955	55-S-1	27	S	83	
305	Costa Rica	08° 13′ N.	83° 21′ W.	Feb. 13, 1955	55-S-1	47	L–S	85	1,000+
306	Gulf of Panama	08° 13′ N.	78° 30′ W.	Feb. 3, 1955	55-S-1	32	L	82	12
307	Gulf of Panama	08° 12′ N.	78° 30′ W.	Feb. 4, 1955	55-S-1	33	N	81.5	8
308	Gulf of Panama	08° 10′ N.	78° 20′ W.	Feb. 7, 1955	55-S-1	39	N	80.5	2–3
309	Gulf of Panama	08° 10′ N.	78° 20′ W.	Feb. 8, 1955	55-S-1	40	N	80	2–10
310	Costa Rica	08° 06′ N.	83° 00′ W.	Feb. 12, 1955	55-S-1	46	H–L	84	11
311	Gulf of Panama	08° 06′ N.	79° 06′ W.	Feb. 6, 1955	55-S-1	37	L	80	9
312	Panama	07° 40′ N.	81° 31′ W.	Feb. 11, 1955	55-S-1	45	S	83	

TABLE 1—Continued

Station Data for All Cruises, February 1952 to May 1959

Collection numbers	General location	Latitude	Longitude	Date mo. day year	Cruise	Station no.	Collection method*	Water temp.	Water depth
313	Panama	07° 39′ N.	81° 58′ W.	Jan. 29, 1955	55-S-1	28	S	84	45–50
314	Costa Rica	07° 38′ N.	83° 23′ W.	Mar. 23, 1954	54-C-1	8	L		
315	Panama	07° 38′ N.	82° 26′ W.	Jan. 28, 1955	55-S-1	25	S	83	100
316	Gulf of Panama	07° 28′ N.	79° 20′ W.	Feb. 9, 1955	55-S-1	42	L	81	1,000+
317	Panama	07° 23′ N.	82° 03′ W.	Jan. 29, 1955	55-S-1	29	S	82	52
318	Panama	07° 22′ N.	80° 56′ W.	Feb. 10, 1955	55-S-1	43	L	84	11
319	Gulf of Panama	07° 22′ N.	78° 17′ W.	June 11, 1957	57-C-3	21	L	84.6	350
320	Panama	07° 19′ N.	81° 50′ W.	Jan. 28, 1955	55-S-1	26	L–M	83	13
321	Gulf of Panama	07° 19′ N.	78° 27′ W.	Feb. 9, 1955	55-S-1	41	S	81	
322	Panama	07° 18′ N.	81° 47′ W.	Feb. 11, 1955	55-S-1	44	L	84	12
323	Panama	07° 18′ N.	81° 38′ W.	Feb. 20, 1958	57-C-6	51	N	81.1	6
324	Gulf of Panama	07° 15′ N.	78° 18′ W.	June 9, 1957	57-C-3	18	L	83.7	1,180
325	Gulf of Panama	07° 13′ N.	78° 20′ W.	June 7, 1957	57-C-3	17	L	83.8	1,058
326	Colombia	07° 06′ N.	78° 10′ W.	June 19, 1957	57-C-3	25	M	84.2	1,000+
327	Colombia	07° 05′ N.	78° 04′ W.	June 6, 1957	57-C-3	16	L	83.1	1,000+
328	Panama	06° 57′ N.	82° 58′ W.	Mar. 22, 1959	59-C-1	10	S	86.5	
329	Costa Rica	06° 56′ N.	81° 29′ W.	Mar. 22, 1954	54-C-1	7	L		
330	Colombia	06° 50′ N.	77° 42′ W.	June 11, 1957	57-C-3	20	M		1,000+
331	Colombia	06° 49′ N.	77° 55′ W.	June 5, 1957	57-C-3	15	L	83.8	1,100+
332	Colombia	06° 45′ N.	78° 49′ W.	May 10, 1959	59-C-1	35	H		
333	Colombia	06° 43′ N.	77° 42′ W.	Feb. 10, 1958	57-C-6	46	H	81.1	65
334	Colombia	06° 40′ N.	77° 50′ W.	June 10, 1957	57-C-3	19	L	83.7	1,100+
335	Colombia	06° 37′ N.	77° 48′ W.	June 20, 1957	57-C-3	26	L		1,200
336	Colombia	06° 25′ N.	77° 48′ W.	June 21, 1957	57-C-3	27	L	84	1,800+
337	Colombia	06° 07′ N.	77° 42′ W.	June 22, 1957	57-C-3	28	L	84	1,815
338	Panama	06° 09′ N.	82° 20′ W.	Mar. 24, 1959	59-C-1	11	L	83.1	
339	Colombia	05° 48′ N.	77° 39′ W.	June 23, 1957	57-C-3	29	L	84.6	1,500+
340	Colombia	05° 36′ N.	77° 44′ W.	Feb. 10, 1958	57-C-6	44	S	80.2	1,323
341	Cocos Is.	05° 34′ N.	87° 04′ W.	Jan. 25, 1955	55-S-1	22	M–L	81	10
342	Cocos Is.	05° 30′ N.	88° 34′ W.	Feb. 21, 1957	57-C-1	20	L	82.8	150
343	Cocos Is.	05° 30′ N.	88° 33′ W.	Feb. 5, 1957	57-C-1	16	L	82	215
344	Cocos Is.	05° 30′ N.	87° 03′ W.	Feb. 25, 1957	57-C-1	22	L	81.5	23
345	Cocos Is.	05° 30′ N.	86° 34′ W.	Jan. 25, 1955	55-S-1	23	S	82	1,000+
346	Cocos Is.	05° 29′ N.	88° 35′ W.	Feb. 23, 1957	57-C-1	21	N–L	82	150
347	Cocos Is.	05° 29′ N.	88° 35′ W.	Mar. 1, 1957	57-C-1	23	L	82.9	200

348	Colombia	05° 28′ N.	77° 53′ W.	June 4, 1957	57-C-3	14	M	82.8	1,100+
349	Colombia	05° 24′ N.	78° 00′ W.	May 6, 1959	59-C-1	34	H		
350	Malpelo Is.	04° 00′ N.	81° 35′ W.	June 2, 1957	57-C-3	13	L	83	45
351	Galapagos Is.	03° 05′ N.	90° 54′ W.	Feb. 7, 1957	57-C-1	17	H	80.4	
352	Galapagos Is.	02° 50′ N.	90° 45′ W.	Sept. 28, 1954	54-C-3	6	L		
353	Ecuador	00° 30′ N.	80° 25′ W.	Feb. 6, 1958	57-C-6	42	S	81.1	214
354	Galapagos Is.	00° 15′ S.	91° 27′ W.	Sept. 9, 1954	54-C-3	2	N		
355	Galapagos Is.	00° 15′ S.	91° 27′ W.	Sept. 27, 1954	54-C-3	5	N		
356	Galapagos Is.	00° 15′ S.	91° 27′ W.	Oct. 20, 1954	54-C-3	7	H		
357	Galapagos Is.	00° 29′ S.	91° 23′ W.	Mar. 7, 1954	54-C-1	5	N		
358	Galapagos Is.	00° 29′ S.	91° 21′ W.	Mar. 17, 1954	54-C-1	6	N		
359	Ecuador	00° 34′ S.	80° 56′ W.	Feb. 12, 1957	57-C-1	18	L	79.9	
360	Ecuador	00° 36′ S.	80° 55′ W.	June 29, 1957	57-C-3	31	L	80	300
361	Galapagos Is.	01° 02′ S.	91° 17′ W.	Mar. 1, 1954	54-C-1	4	N		
362	Ecuador	01° 17′ S.	81° 16′ W.	July 5, 1957	57-C-3	33	M	80.4	1,000+
363	Ecuador	01° 30′ S.	84° 30′ W.	Nov. 18, 1957	57-C-5	1	M	78.0	
364	Ecuador	01° 32′ S.	81° 10′ W.	June 30, 1957	57-C-3	32	L	79.0	91
365	Ecuador	01° 50′ S.	81° 11′ W.	Jan. 17, 1958	57-C-5	24	L	79.0	
366	Gulf of Guayaquil	02° 15′ S.	81° 15′ W.	May 4, 1959	59-C-1	33	N	76.9	
367	Gulf of Guayaquil	02° 16′ S.	81° 10′ W.	Oct. 27, 1958	58-C-3	35	S	71.7	96
368	Gulf of Guayaquil	02° 28′ S.	83° 07′ W.	Sept. 4, 1958	58-C-3	4	M		
369	Gulf of Guayaquil	02° 32′ S.	81° 03′ W.	Oct. 26, 1958	58-C-3	34	M	72.3	63
370	Gulf of Guayaquil	03° 06′ S.	80° 50′ W.	Oct. 20, 1954	54-C-3	9	H		
371	Gulf of Guayaquil	03° 13′ S.	81° 02′ W.	Oct. 21, 1954	54-C-3	10	L		
372	Gulf of Guayaquil	03° 11′ S.	80° 15′ W.	Oct. 9, 1958	58-C-3	23	L	74.8	42
373	Gulf of Guayaquil	03° 22′ S.	81° 01′ W.	Oct. 31, 1958	58-C-3	37	S	72.1	188
374	Gulf of Guayaquil	03° 26′ S.	80° 52′ W.	Oct. 9, 1958	58-C-3	24	H		42
375	Gulf of Guayaquil	03° 30′ S.	81° 10′ W.	Nov. 24, 1957	57-C-5	4	L	73.0	
376	Gulf of Guayaquil	03° 30′ S.	81° 10′ W.	Nov. 26, 1957	57-C-5	5	L	74.0	
377	Gulf of Guayaquil	03° 30′ S.	81° 10′ W.	Nov. 28, 1957	57-C-5	8	L	73.0	
378	Gulf of Guayaquil	03° 30′ S.	81° 10′ W.	Dec. 2, 1957	57-C-6	6	S	73.8	60
379	Gulf of Guayaquil	03° 30′ S.	81° 10′ W.	Dec. 4, 1957	57-C-6	8	H	73.6	55
380	Gulf of Guayaquil	03° 32′ S.	81° 10′ W.	Feb. 12, 1954	54-C-1	3	L		
381	Gulf of Guayaquil	03° 37′ S.	80° 44′ W.	Oct. 12, 1958	58-C-3	28	S	74.1	35
382	Gulf of Guayaquil	03° 42′ S.	80° 56′ W.	Oct. 11, 1958	58-C-3	27	L	74.1	50
383	Gulf of Guayaquil	03° 43′ S.	80° 45′ W.	Nov. 23, 1957	57-C-5	2	L	76.0	
384	Gulf of Guayaquil	03° 43′ S.	80° 45′ W.	Nov. 24, 1957	57-C-5	3	M		
385	Gulf of Guayaquil	03° 43′ S.	80° 45′ W.	Nov. 27, 1957	57-C-5	7	L	75.0	
386	Gulf of Guayaquil	03° 45′ S.	80° 58′ W.	Oct. 10, 1958	58-C-3	26	L	74.1	88
387	Gulf of Guayaquil	03° 47′ S.	80° 50′ W.	April 27, 1959	59-C-1	28	N		
388	Gulf of Guayaquil	03° 51′ S.	80° 53′ W.	April 27, 1959	59-C-1	27	N	76.0	
389	Gulf of Guayaquil	03° 51′ S.	80° 53′ W.	May 3, 1959	59-C-1	32	N	75.2	
390	Gulf of Guayaquil	03° 52′ S.	80° 51′ W.	Dec. 6, 1957	57-C-6	9	N	72.7	3

TABLE 1—Continued

Station Data for All Cruises, February 1952 to May 1959

Collection numbers	General location	Latitude	Longitude	Date mo. day year	Cruise	Station no.	Collection method*	Water temp.	Water depth
391	Gulf of Guayaquil	04° 04′ S.	81° 02′ W.	April 22, 1959	59-C-1	23–24	N–L	68.8	
392	Gulf of Guayaquil	04° 04′ S.	81° 02′ W.	April 23, 1959	59-C-1	25	N	68.6	
393	Gulf of Guayaquil	04° 10′ S.	81° 38′ W.	Oct. 19, 1958	58-C-3	30	S	71.7	1,500
394	Gulf of Guayaquil	04° 10′ S.	81° 38′ W.	Oct. 20, 1958	58-C-3	31	L		1,500
395	Gulf of Guayaquil	04° 11′ S.	82° 18′ W.	Sept. 4, 1958	58-C-3	5	N–L	68.5	
396	Gulf of Guayaquil	04° 11′ S.	81° 10′ W.	April 15, 1959	59-C-1	20	N–L	69.6	
397	Peru	04° 34′ S.	81° 17′ W.	Nov. 28, 1957	57-C-6	3	L		
398	Peru	05° 01′ S.	81° 15′ W.	April 1, 1959	59-C-1	12	N	69.0	
399	Peru	05° 01′ S.	81° 15′ W.	April 2, 1959	59-C-1	13	N	69.0	
400	Peru	05° 15′ S.	82° 50′ W.	Dec. 1, 1957	57-C-6	5	M	71.6	2,065
401	Peru	05° 51′ S.	81° 09′ W.	Oct. 21, 1958	58-C-3	32	L	61.7	16
402	Peru	06° 55′ S.	80° 44′ W.	Jan. 14, 1958	57-C-6	35	L	73.4	18
403	Peru	06° 55′ S.	80° 44′ W.	Jan. 15, 1958	57-C-6	36	H	74.1	1–7
404	Peru	06° 55′ S.	80° 44′ W.	Jan. 16, 1958	57-C-6	37	H–N	74.1	5–18
405	Peru	06° 55′ S.	80° 44′ W.	Jan. 17, 1958	57-C-6	38	H	74.7	1
406	Peru	08° 13′ S.	80° 38′ W.	April 29, 1959	59-C-1	29	H		
407	Peru	08° 14′ S.	78° 58′ W.	Nov. 3, 1958	58-C-3	38	L	59.1	6
408	Peru	08° 18′ S.	79° 02′ W.	April 4, 1959	59-C-1	15	N	65.5	
409	Peru	08° 18′ S.	79° 02′ W.	April 9, 1959	59-C-1	17	N	67.5	
410	Peru	08° 18′ S.	79° 02′ W.	April 19, 1959	59-C-1	21	N	65.7	
411	Peru	08° 26′ S.	78° 57′ W.	Nov. 29, 1957	57-C-6	4	N	64.0	6
412	Peru	08° 39′ S.	78° 56′ W.	Jan. 13, 1958	57-C-6	34	N	67.8	57
413	Peru	08° 47′ S.	78° 51′ W.	Jan. 12, 1958	57-C-6	33	N	70.4	23
414	Peru	08° 49′ S.	80° 17′ W.	April 30, 1959	59-C-1	30	S	74.3	
415	Peru	08° 51′ S.	78° 48′ W.	Jan. 11, 1958	57-C-6	31	N	73.4	40
416	Peru	08° 51′ S.	78° 48′ W.	Jan. 11, 1958	57-C-6	32	L	73.2	36
417	Peru	09° 00′ S.	79° 00′ W.	Nov. 27, 1957	57-C-5	6	N		
418	Peru	09° 00′ S.	79° 00′ W.	Dec. 5, 1957	57-C-5	10	N	64.0	
419	Peru	09° 00′ S.	79° 00′ W.	Jan. 13, 1958	57-C-5	23	N	74.0	
420	Peru	09° 03′ S.	79° 55′ W.	Dec. 22, 1957	57-C-5	17	S	72.0	
421	Peru	09° 03′ S.	79° 55′ W.	Jan. 12, 1958	57-C-5	22	L		
422	Peru	09° 05′ S.	79° 57′ W.	Sept. 15, 1958	58-C-3	10	S	65.1	40
423	Peru	09° 05′ S.	79° 57′ W.	Nov. 5, 1958	58-C-3	40	S	67.2	50
424	Peru	09° 05′ S.	79° 57′ W.	April 4, 1959	59-C-1	14	N	77.2	
425	Peru	09° 05′ S.	79° 57′ W.	April 12, 1959	59-C-1	18	L	76.7	
426	Peru	09° 05′ S.	79° 57′ W.	April 14, 1959	59-C-1	19	S	75.9	

427	Peru	09° 05′ S.	79° 57′ W.	May 2, 1959	59-C-1	31	L	81.2		
428	Peru	09° 05′ S.	79° 56′ W.	Sept. 20, 1958	58-C-3	13A	S	65.3	55	
429	Peru	09° 07′ S.	80° 01′ W.	Dec. 22, 1957	57-C-6	24	S	73.0		
430	Peru	09° 12′ S.	79° 34′ W.	Sept. 20, 1958	58-C-3	13B	L	65.3	60	
431	Peru	09° 31′ S.	78° 26′ W.	Dec. 21, 1957	57-C-6	23	N	68.9	42	
432	Peru	10° 31′ S.	77° 56′ W.	Sept. 16, 1958	58-C-3	12	L	59.5	10	
433	Peru	10° 36′ S.	77° 51′ W.	Oct. 16, 1958	58-C-3	29	N		11	
434	Peru	10° 36′ S.	77° 51′ W.	Sept. 13, 1958	58-C-3	8	N		60	
435	Peru	10° 39′ S.	77° 51′ W.	Oct. 23, 1958	58-C-3	33	N		8	
436	Peru	10° 41′ S.	77° 51′ W.	Sept. 16, 1958	58-C-3	11	N		5	
437	Peru	11° 15′ S.	77° 50′ W.	Sept. 25, 1958	58-C-3	15	L	59.9	63	
438	Peru	11° 27′ S.	77° 18′ W.	Dec. 8, 1957	57-C-6	10	N	70.5	52	
439	Peru	12° 00′ S.	77° 41′ W.	Dec. 20, 1957	57-C-6	22	H	69.6	98	
440	Peru	12° 01′ S.	77° 12′ W.	Sept. 9, 1958	58-C-3	6A	N		5	
441	Peru	12° 03′ S.	77° 11′ W.	Jan. 20, 1958	57-C-6	39	L	69.6	9	
442	Peru	12° 04′ S.	77° 14′ W.	Sept. 8, 1958	58-C-3	6	N	59.2	45	
443	Peru	12° 04′ S.	77° 10′ W.	Jan. 24, 1958	57-C-6	40	L	68.0	6	
444	Peru	12° 01′ S.	77° 10′ W.	Jan. 28, 1958	57-C-6	41	N	68.2	6	
445	Peru	12° 04′ S.	77° 10′ W.	Sept. 27, 1958	58-C-3	16	L	58.3	6	
446	Peru	12° 01′ S.	77° 10′ W.	Sept. 28, 1958	58-C-3	17	H	58.6	6	
447	Peru	12° 04′ S.	77° 10′ W.	Sept. 29, 1958	58-C-3	18	L	59.3	6	
448	Peru	12° 05′ S.	77° 10′ W.	Sept. 9, 1958	58-C-3	6B	L	69.0	6	
449	Peru	13° 30′ S.	76° 18′ W.	Sept. 5, 1958	58-C-3	21	N	62.6	6	
450	Peru	13° 44′ S.	76° 25′ W.	Jan. 8, 1958	57-C-6	30	N	67.8	57	
451	Peru	13° 45′ S.	76° 16′ W.	Oct. 4, 1958	58-C-3	19	N	63.5	6	
452	Peru	13° 46′ S.	76° 18′ W.	Oct. 4, 1958	58-C-3	20	N			
453	Peru	15° 16′ S.	75° 25′ W.	Dec. 25, 1957	57-C-6	25	N	65.3	120	
454	Peru	15° 40′ S.	74° 45′ W.	Dec. 18, 1957	57-C-5	16	N	62.0		
455	Peru	15° 53′ S.	74° 15′ W.	Dec. 10, 1957	57-C-6	11	N	61.7	90	
456	Peru	17° 00′ S.	72° 08′ W.	Jan. 7, 1958	57-C-5	20	L			
457	Peru	17° 03′ S.	72° 05′ W.	Dec. 11, 1957	57-C-6	12	N	65.8	70	
458	Peru	17° 16′ S.	71° 46′ W.	Dec. 14, 1957	57-C-6	17	N	63.9	210	
459	Peru	17° 30′ S.	71° 30′ W.	Jan. 1, 1958	57-C-6	27	N	68.9	284	
460	Peru	17° 38′ S.	71° 18′ W.	Jan. 15, 1958	57-C-6	19	N	61.9	70	
461	Peru	17° 39′ S.	71° 18′ W.	Dec. 15, 1957	57-C-6	20	N	61.9	80	
462	Peru	17° 40′ S.	71° 20′ W.	Dec. 13, 1957	57-C-6	16	L	65.7	15	
463	Peru	17° 41′ S.	71° 18′ W.	Dec. 13, 1957	57-C-5	12	N	66.0		
464	Peru	17° 41′ S.	71° 18′ W.	Dec. 14, 1957	57-C-5	13	N-L	66.0		
465	Peru	17° 41′ S.	71° 18′ W.	Dec. 16, 1957	57-C-5	14	M			
466	Peru	17° 41′ S.	71° 18′ W.	Dec. 14, 1957	57-C-6	18	L	63.1	20	
467	Peru	17° 42′ S.	71° 21′ W.	Dec. 11, 1957	57-C-6	13	N	65.3	180	
468	Chile	19° 35′ S.	70° 24′ W.	Dec. 12, 1957	57-C-6	14	H	72.5	480	
469	Chile	19° 45′ S.	70° 35′ W.	Dec. 10, 1957	57-C-5	11	L	71.0		
470	Chile	20° 25′ S.	70° 50′ W.	Dec. 26, 1957	57-C-5	18	L	75.0		
471	Chile	20° 25′ S.	70° 50′ W.	Dec. 27, 1957	57-C-5	19	L	75.0		
472	Chile	20° 25′ S.	70° 43′ W.	Jan. 5, 1958	57-C-6	29	L	73.0	681	

* H—hook and line, N—bait net, L—night light, S—stomach contents, M—miscellaneous

LIST OF SPECIMENS

The list of specimens (Table 2) has been arranged systematically by family and alphabetically by genus within each family, with slight modification of the classification system used by the California Academy of Sciences. Scientific names generally follow Meek and Hildebrand (1923-28) and Hildebrand (1946), except for groups with more recent revisions.

Each fish name is followed by letters and pairs of numbers; letters refer to collecting methods. The first number of each pair is a collection number and the second, in parentheses, represents the total individuals of that species collected at that station by the given method. Thus, under the family Triakidae, it will be seen that a hook and line was used to collect one (1) *Mustelus* sp., and the collection number is 49. Table 1 informs the reader that collection 49 was made at station 38 (cruise designated 56-C-1) which was occupied April 30, 1956 in the Gulf of California; all fish were captured in 10 fathoms of water, and the sea-surface temperature was 66° F.

Most of the specimens listed have been placed in the fish collections, Department of Zoology, University of California, Los Angeles; others have been retained at the State Fisheries Laboratory or sent to individuals or institutions specializing in a particular species or group.

At many of the night-light stations, postlarval, juvenile, and young fish were taken. Specific identifications for some of these were not determined.

TABLE 2

List of Specimens Collected, February 1952 to May 1959

Triakidae—Smoothhounds
Mustelus sp. H49(1)
Carcharhinidae—Requiem Sharks
Carcharhinus porosus N297(1)
Carcharhinus remotus N411(1)
Carcharhinus sp. H136(1)
Sphyrnidae—Hammerheads
Sphyrna zygaena N34(1), N412(1), N450(1)
Sphyrna sp. N110(1)
Dasyatidae—Stingrays
Dasyatis brevis N452(1)
Urolophus halleri L68(1)
Urotrygon asterias N300(1)
Urotrygon serrula N392(1)
Urotrygon sp. N388(1)
Myliobatidae—Eagle Rays
Myliobatis californicus N6(2)
Myliobatis peruvianus N424(1), N449(1)
Elopidae—Tenpounders
Elops affinis N64(2), L118(1)
Albulidae—Bonefishes
Albula vulpes N22(4), N76(1), L443(1)
Dussumieriidae—Round Herrings
Etrumeus acuminatus N30(3), N56(1) N62(2), N76(2), N96(19), L260(1)
Clupeidae—Herrings
Harengula peruana L402(8)
Harengula thrissina L103(9), L104(5), L105(1), L106(1), L108(1), N117(1)
Harengula sp. L322(2)
Ilisha furthi L365(1), N387(2)
Lile stolifera L121(64), L184(1), L320(16), N419(3)
Odontognathus panamensis N294(1), N301(1)
Opisthonema spp. N17(4), N38(3), L52(1), N62(1), N72(1), N74(4), N81(7), N110(2), N114(12), N116(2), N117(6), L162(1), L177(4), L225(1), L280(1), L291(4), L295(2), N301(1), N307(42), H310(7), L311(2), L318(15), N357(6), N387(3), N390(6), L396(4)
Opisthopterus dovii N49(8), N50(3), N117(1), N294(1), N299(1), N301(2), N308(3), L311(2)
Opisthopterus equatorialis N387(2)
Opisthopterus sp. N288(1), N299(2), N301(1)
Sardinops caerulea N5(9), N7(22), N10(2), N11(1), S15(4), N24(1), N30(9), N31(10), N33(30),

TABLE 2—Continued

List of Specimens Collected, February 1952 to May 1959

Clupeidae—Herrings—Continued
Sardinops caerulea—Continued
N34(13), N35(16), N37(16), S39(1), N42(1), N56(3), N76(7), N81(1)
Sardinops sagax N354(6), N357(6)
Clupeids L13(1), L20(1), L44(4), L53(74), L59(6), L67(8), L121(4) S164(3), L200(2), L210(30), L223(7), L247(12), L260(1), L262(4), L280(4), L291(57), L295(25), L303(66), L306(11), S313(1), L339(3), L341(350+), L380(9), L402(2), N413(2), S414(8), N431(2), N460(11)

Engraulidae—Anchovies
Anchoa arenicola N79(1), L303(23), L320(2)
Anchoa ischana N17(1), L177(1)
Anchoa mundeoloides N50(1)
Anchoa naso N110(3)
Anchoa nasus N415(3)
Anchoa panamensis N17(2), N49(1), N308(2)
Anchoa spinifer N301(2), N308(1)
Anchoa starksi N62(3), N63(2), N297(19)
Anchoa sp. N17(1), N80(35), L280(4), L284(1), N299(4), N300(2), N301(4), L311(4), N388(1), N436(1)
Anchovia macrolepidota N49(2)
Cetengraulis mysticetus N17(2), N79(9), N80(29), N82(8), N114(1), N117(9), L177(5), S217(2), N296(1), N299(2), N308(105), L311(400), N387(18), N388(25), N389(19), N391(31), N392(7), L396(1), N396(47), N398(96), N399(68), S426(28).
Engraulis mordax N1(1), N2(47), N4(1), N6(42), N9(50), L14(2), L15(13), N24(39), N25(17), N30(2), N31(42), N33(2), N34(12), N36(58), S41(9), N42(42), L44(15), N62(4), N63(2), N76(2)
Engraulis ringens L401(3), L407(1), N408(43), N410(23), N411(24), N413(33), N417(1), N418(2), N419(4), N434(300), L437(2), N438(23), N442(7), N450(26), N454(2), N455(30), N457(72), N463(2), L464(2), M465(11), L466(1), N467(19).
Lycengraulis poeyi N300(1), N301(1)

Engraulids L13(1), N21(1), L53(1), L69(4), L95(1), N96(1), L97(9), L103(1), L104(1), L105(1), N116(1), N117(7), L162(1), L184(125), L280(62), L284(6), L291(27), L295(6), S298(54), L303(4), S303(12), L310(12), L311(36), S313(7), L318(9), L322(1), N392(1), S422(2)

Argentinidae—Deepsea Smelts
Bathylagus sp. S423(8)
Leuroglossus stilbius S420(2), S429(35)

Sternoptychidae—Lightfishes
Sternoptyx diaphana S393(12)
Vinciguerria lucetia S149(67), S185(100), L194(1), S205(1), S241(1), L334(1), L337(1), N361(29), L377(1), S423(11), S429(30)

Ariidae—Sea Catfishes
Bagre panamensis N79(4), N283(6), L291(2), N301(1), N392(4)
Bagre pinnimaculatus N17(1), H280(1)
Bagre sp. H279(3), N299(2)
Galeichthys peruvianus N435(1), N436(1)
Netuma sp. N299(2)
Ariids N99(2), N296(1), N301(1)

Scomberesocidae—Sauries
Cololabis adocetus L375(2), L376(3), L402(1), L421(21), L471(2)
Cololabis saira L3(28), L8(10), N11(1), L29(25), L75(6), L95(2), L430(1)
Scomberesox saurus N459(1), L472(1)

Hemiramphidae—Halfbeaks
Euleptorhamphus viridis L229(1), L247(1), L263(4), L341(1)
Hemiramphus saltator L275(2), L286(4)
Hemiramphus sp. L161(1)
Hyporhamphus snyderi L68(3), N290(1), L295(10), L297(4), N299(6), N301(1), N309(1), L318(9)
Hyporhamphus unifasciatus N49(1), L59(1), N60(1), L67(1), N117(1), L121(1), L291(2), N387(9), L391(3)
Hyporhamphus sp. L172(1), L269(1), L327(2), L385(3)
Hemiramphids L255(1)

Belonidae—Needlefishes
Ablennes hians N74(1), H162(2)
Belone persimilis L44(1), L125(1), L126(1), L141(2), L263(1), L275(5), L291(3), L306(1), L341(1)
Strongylura exilis N42(1), L44(1), L68(1), L69(1), L146(1),

TABLE 2—Continued

List of Specimens Collected, February 1952 to May 1959

Belonidae—Needlefishes—Continued
Strongylura exilis—Continued
L280(1), L303(1), N309(1), L318(1), N387(1), L396(1)
Strongylura fodiator L275(1), L306(1)
Strongylura pacifica L322(1), L341(3), L350(1)
Strongylura scapularis L20(3), N61(5), L64(1), L295(5), L432(3)
Strongylura stolzmanni L223(1)
Strongylura sp. N290(1), L291(6), N399(1)
Belonids S261(2)

Exocoetidae—Flyingfishes
Cypselurus sp. M43(2), M98(3), L125(5), L130(1), L141(1), L146(3), M152(2), L171(1), L182(1), S190(1), L191(2), L194(1), L200(2), L207(1), L210(1), L254(3), L258(1), L269(1), L350(1), M362(2), M363(1), L364(1)
Danichthys rufipinnis L427(1)
Danichthys sp. L148(2), M362(3)
Exocoetus monocirrhus L206(1), L216(1), L236(1), L264(2), L273(2), L341(1)
Exocoetus sp. L200(5), L210(6), L238(1), L269(8), L360(4), M362(2), L425(1)
Fodiator acutus N42(6), L53(1), L59(2), N60(3), L64(3), N74(4), L75(2), N110(2), N117(2), L121(1), L161(1), L172(1), L225(1), L273(1), L281(2), L291(2), L295(9), L297(1), L303(2), L310(1), H310(1), L318(1), L421(1)
Oxyporhamphus micropterus L100(3), L105(1), L107(2), L122(1), L126(4), L127(1), L128(49), L132(6), L133(6), L137(2), L139(6), L140(3), S144(3), L145(1), L148(13), L154(3), L155(1), L157(5), L158(19), S165(1), L166(3), S167(4), L171(1), L175(4), L182(7), S185(2), L186(5), S189(1), S190(3), L193(2), L194(23), L195(1), S196(5), L199(14), L200(2), L201(7), L203(1), L206(4), L207(2), L210(4), L214(3), L219(1), L221(4), L223(1), L225(9), L230(2), L246(2), L247(20), L258(3), L260(2), L262(8), L265(5), L267(2), L269(11), L270(3), L276(15), L286(4), L314(11), L316(1), L319(2), L325(2), L331(1), L337(3), L343(3), L347(1), L350(1), L352(3), L360(2), L371(1)
Parexocoetus sp. L223(1), L287(1)
Prognichthys gibbifrons M197(1), L314(4)
Prognichthys sp. L155(1), L156(10), L157(1), L166(1), L178(1), L182(1), L200(5), L210(1), M252(1), L269(2), L331(3), L337(1)
Exocoetids M46(1), L95(3), L97(2), L100(8), L102(1), L108(3), N117(1), L126(3), L127(2), L131(1), L137(2), L138(1), L139(3), L140(4), L158(7), S167(1), L168(1), L193(1), S205(1), L210(4), L219(1), L225(2), L226(1), L230(3), L235(1), L236(1), L247(3), L249(3), L267(2), L276(5), L278(2), L286(24), L295(1), L305(1), L306(1), L310(5), L316(1), L325(1), M400(2), S429(1), H439(1), N467(3)

Synodidae—Lizardfishes
Synodus lucioceps N11(3), L15(44), N24(1), N25(2), N35(2), N38(2), N54(1), N60(1), N62(1)
Synodus scituliceps N21(1), N22(1), N392(1)
Synodus sechurae N74(1)
Synodus sp. L102(6), L104(5), L105(10), S119(1), L121(1), L122(1), L156(1), S205(2), L210(3), L223(2), L246(3), L249(2), L262(27), L263(3), L265(1), L268(1), L269(18), L270(8), L276(5), L286(1), L291(1), L293(1), L303(3), S313(4), L318(1), L320(1), L322(1), L325(2), L329(3), L336(21), L337(1), L339(1), L341(4), L344(8), L350(1), S381(1), L382(1)

Myctophidae—Lanternfishes
Benthosema panamense S205(1), L265(7), L276(21), S305(7), S429(10)
Diaphus sp. L394(1)
Gonichthys cocco L26(1), L94(1), L138(3), L139(L), L285(1), L276(8), L305(1), L316(16), L325(5), L327(2), L329(3), L331(2), L334(7), L335(1), L336(4), L337(1), L339(1), L342(1), L343(4), L346(1), L347(1), L350(1), L375(3), L377(2), L421(2)
Hygophum reinhardti L26(1), L95(1), L126(1), L127(2),

TABLE 2—Continued

List of Specimens Collected, February 1952 to May 1959

Myctophidae—Lanternfishes—Continued
Hygophum reinhardti—Continued
L134(1), L138(2), L139(1), L140(1), L258(1)
Lampanyctus sp. L337(1), S429(3)
Myctophum affine L12(1), L26(2), L130(1), L131(2), L154(1), L171(1), L178(3), L182(1), L233(4), L269(2), L327(1), L329(1), L334(2), L335(1), L336(1), L339(1), L342(26), L343(12), L346(8), L347(5), L352(3), L365(4), L375(2), S420(20), L469(50), L470(6), L471(23), L472(6)
Myctophum aurolaternatum L107(1), L127(3), L193(1), L206(1), L258(1), L269(3), L327(1), L331(2), L339(1), L342(7), L343(11), L346(7), L347(1)
Myctophum californiense L352(1)
Myctophum ereymanni L235(1), L269(10), L316(2), L336(25), L337(3), L339(1), L342(2), L343(1)
Myctophids S124(1), S204(385), S277(100)
Paralepidae—Barracudinas
Lestidium pacificum L276(1)
Lestidium sp. S245(1)
Notolepis coruscans S271(2)
Paralepids S198(1), S274(4)
Myrophidae—Worm Eels
Myrophis rager S261(1)
Ophichthidae—Snake Eels
Ophichthus pacifici L407(4), L441(1), L443(6), L448(1)
Ophichthus sp. H121(1), N294(1)
Muraenidae—Morays
Gymnothorax dorii N88(1)
Priodonophis angusticeps H405(1)
Muraenids N294(1), M320(1)
Gadidae—Cods
Merluccius gayi S428(1)
Gadids S393(2)
Bregmacerotidae—Threadfin Codlings
Bregmaceros bathymaster L102(3), L104(5), L105(5), L156(4), S205(28), S216(14), S220(4) L223(3), S241(8), L246(15) L247(1), L260(44), S261(31), L263(2), L265(2), L266(15), L293(9), L327(2), L335(1)
Trachipteridae—Ribbonfishes
Zu cristatus S313(1)
Trachipterid S164(1)
Holocentridae—Squirrelfishes
Holocentrus suborbitalis L127(1), L230(4), L268(1), L376(1)
Myripristis occidentalis L107(2), L137(1), L139(2), L145(1), L148(11), L155(2), L203(3), L206(1), S212(1), S213(1), L225(1), L235(1), L276(1), L258(1), L260(1), L262(2), L269(75), S271(1) L275(2), L286(1), S305(1), L305(3), L310(2), L314(4), L316(10), L322(2), L336(1), L337(1)
Myripristis poecilopus L107(1)
Myripristis sp. L154(1), L168(1)
Holocentrids L105(4), L175(19), L193(4), L229(1), L230(2), L236(2), L342(3), L347(1)
Bothidae—Lefteyed Flounders
Citharichthys gilberti S381(43)
Etropus crossotus N22(1), N50(2), N74(1), N80(2), N300(1)
Paralichthys aestuarius N17(1)
Syacium ovale N308(2)
Bothids S381(15)
Pleuronectidae—Righteyed Flounders
Pleuronectid L336(1)
Achiridae—Broad Soles
Achirus fonsecensis N300(1)
Achirus mazatlanus N300(3)
Cynoglossidae—Tonguefishes
Symphurus elongatus N50(3), N299(1), N301(1)
Symphurus sp. N49(1), L407(1), N433(3)
Lobotidae—Tripletails
Lobotes pacificus N113(1), H143(1), L235(1), N301(1)
Serranidae—Basses
Alphestes fasciatus H403(1)
Anthias sp. L425(1)
Diplectrum pacificum H51(1)
Epinephelus analogus H279(1)
Epinephelus labriformis N404(1)
Mycteroperca olfax N354(1), N355(1), H356(1)
Mycteroperca pardalis H78(1), N85(1)
Mycteroperca xenarcha H57(3)
Paralabrax albomaculatus H356(1)
Paralabrax callaensis H403(2)
Paralabrax clathratus H16(1)
Paralabrax humeralis H403(2), H404(1)
Paralabrax maculatofasciatus H40(2), N76(2)
Paralabrax nebulifer H16(1), H40(8)
Paranthias colonus N354(1), N355(2)
Prionodes sp. S381(1)
Serranids L13(3), S124(4), S205(1), S213(1), S215(1), S239(2), S245(1), S259(1), S261(1), L265(1), S271(2), S274(2), L303(1), S313(18), L318(1), S321(1), L341(5)

TABLE 2—Continued

List of Specimens Collected, February 1952 to May 1959

Apogonidae—Cardinalfishes
Apogon dovii L318(1), M320(5), L341(1), N419(1)
Apogon parri N173(2)
Apogonids L53(1), L160(22)
Centropomidae—Robalos
Centropomus robalito L284(1)
Mullidae—Goatfishes
Pseudupeneus grandisquamis N84(2), L108(1), N114(1), S164(5), N173(1), L180(2), L260(1), S205(1), L207(1), L223(1), L225(9), S255(1), L262(4), L263(3), L269(5), L273(10), S282(6), L286(7), L303(5), L305(13), S305(2), L306(1), L310(2), S312(12), S313(7), L316(5), L320(1), L322(6), L325(1), L331(8), L334(1), L335(2), L336(25), L337(7), L339(4), L341(2), L350(1), L364(17), L386(1), N389(1), L396(1)
Atherinidae—Silversides
Atherinops affinis L14(3), N24(1), L44(29), L53(1), L59(1), L64(3)
Atherinopsis californiensis N6(1), M368(1)
Austromenidia regia L402(8), L432(23), L437(52), L441(28), N442(8), L445(1), L448(31), N451(4), N453(1), L456(5), N460(1), N461(2), N463(1), L464(2), M465(4), L466(1)
Eurystole eriarcha L141(2)
Kirtlandia gilberti L13(4), L291(1)
Kirtlandia pachylepis N300(1)
Kirtlandia sp. L134(1)
Leuresthes tenuis N2(1)
Menidia starksi L103(3), L105(1), L162(8), L275(7), L320(1), L322(3)
Mugilops cyanellus L103(1), L104(4), L291(7), L311(2), L341(9)
Mugilops marinus L344(3)
Mugilops sp. L102(3)
Nectarges aepenthe L432(1)
Mugilidae—Mullets
Chaenomugil proboscideus L146(3)
Mugil cephalus N73(1), L407(2), N458(1), N460(1)
Mugil curema N301(1)
Mugil hospes N299(1)
Mugil sp. L20(2), L44(1), L53(6), L59(4), L64(1), L69(41), L94(3), L100(6), L102(3), L104(3), L105(32), L106(2), L108(11), L121(3), L126(1), L128(16), L133(5), L138(1), L142(2), L148(6), L155(3), L156(4), L158(3), L159(3), L160(2), L162(19), L168(5), N170(39), L172(2), L179(2), L184(5), L193(1), L194(1), L195(1), L200(9), L210(7), S213(1), L214(2), L218(1), L219(1), M222(1), L223(26), L225(9), L226(5), L230(1), L233(1), L235(10), L236(4), L238(3), L243(2), L244(1), M245(3), L246(33), L249(4), L255(17), L260(10), L262(2), L263(4), L264(3), L265(1), L266(1), L269(6), L275(6), L276(9), L280(4), L281(8), L283(12), L284(26), L286(20), N290(18), L291(193) L293(1), L295(39), L297(1), L303(65), L305(2), L306(15), L311(2), S313(6), L314(7), L316(2), L318(1), L319(3), L320(8), S321(3), L322(6), N323(3), L324(3), L325(13), L327(1), L331(1), L335(1), L336(7), L337(4), L339(9), I 341(3), L344(4), L350(8), L359(8), L364(25), L365(1), L372(8), L375(11), L376(2), L380(11), L382(16), L383(11), L386(15), L391(2), L396(1), L401(1), L402(2), N404(4), L407(5), N413(7), N415(36), L416(4), L421(5), N431(9), L437(1), L441(30), L445(6), L447(66)
Sphyraenidae—Barracudas
Sphyraena argentea N7(2) ,
Sphyraena ensis N117(5), H183(1), H310(4), N398(1)
Sphyraena idiastes N387(2), N392(7), N404(1)
Sphyraena sp. N76(1)
Polynemidae—Threadfins
Polydactylus approximans L53(2), L100(5), L105(15), L107(20), L108(4), L155(37), L156(13), L168(80), L194(1), L195(1), L200(2), L201(2), S205(2), L206(1), L207(10), L210(26), S213(15), L214 (3), L219(5), L221(9), L223(12), L225(2), L228(4), L230(14), L235(6), L236(4), L238(1), L243(1), S245(1), L246(10), L247(55), L249(12), L260(2), L265(29), L266(2), L269(33), L270(4), L273(13), N290(2), N294(2), N300(2), N301(1), L303(9), L305(7), L310(1), S313(1), L314(200), L316(1), L318(1), L319(6), S321(13), L322(1), L324(2), L325(3), L327(4), L331(3), L334(2), L335(11), L336(35), L337(5), L339(2),

TABLE 2—Continued

List of Specimens Collected, February 1952 to May 1959

Polynemidae—Threadfins—Continued
Polydactylus approximans—Cont. S340(1), L350(2), L359(1), L364(12), L365(3), L371(1), L372(1), L380(4), L382(2), L386(1), N392(1)
Polydactylus opercularis N22(1), S101(1), L107(5), L108(2), N111(4), N113(2), N117(1), L155(1), L168(2), L177(1), L179(2), L216(30), S217(2), L219(3), L221(10), L223(3), L225(5), L226(1), L233(3), L235(3), L236(3), L238(1), S239(15), M245(7), N251(10) L260(5), L273(2), N301(3), L305(1), L314(100), S315(17), L316(2)
Polydactylus sp. S215(2)
Gerridae—Jennies
Diapterus peruvianus N392(1)
Diapterus sp. N114(4)
Eucinostomus argenteus N21(6), N54(1), N76(1)
Eucinostomus elongatus L177(2)
Eucinostomus gracilis N170(27), L180(6), L284(1)
Eucinostomus sp. L200(1), L247-(32), L268(1), L303(9), L324(1), L335(2), L336(3), L339(1), L364-(9)
Eugerres sp. N114(1)
Gerres cinereus N22(1)
Gerrids N50(1), L236(2)
Nematistiidae—Roosterfishes
Nematistius pectoralis N42(1), L310(3)
Carangidae—Jacks
Alectis ciliaris N42(2), L175(1), L180(1), L210(8), N290(1), N417(1)
Caranx caballus N77(1), L100(4), L104(1), N112(3), H125(2), L126(1), L146(1), L155(17), S174(1), S208(4), L218(1), L219(3), L221(5), L223(3), M227(3), L229(3), L230(1), N232(1), L235(11), M242(6), L243(1), L247(1), M250(1), L258(1), L270(4), S317(1), L320(2), L325(1), L331(1), L335(1), L350(1)
Caranx caninus N110(1), H183(1), L219(2), L230(2), H302(1), H370(1)
Caranx hippos N232(1), N399(1)
Caranx vinctus L122(1), S213(3), L223(3), L286(1), L295(1)
Caranx sp. N117(2), L155(1), L176(1), L179(1), L180(1), S209(1), S220(1), S224(5), L237(1), S239(1), S245(1), L246(4), L247(1), L249(2), N290(2), L314(1), L334(2), L371(1)
Chloroscombrus orqueta N50(2), N72(1), L104(1), N116(2), N117(9), L146(1), N173(1), L177(4), L180(2), S205(36), S213(1), L235(2), S239(3), S240(1), S245(2), N285(2), N290(4), N296(1), N299(4), N300(1), N309(3), S313(2), L341(1), N387(6), N413(1)
Citula dorsalis L322(1)
Decapterus pinnulatus N111(4)
Decapterus sp. L126(1), L177(1), L180(2), S187(1), S205(27), S212(1), S239(1), S259(1), S271(1)
Elagatis bipinnulatus H169(1), L247(2), N323(2), L341(1), M341(1)
Hemicaranx leucurus N49(1)
Hemicaranx zelotes N49(1)
Naucrates ductor S205(7), S213(1), M227(3), L230(1), N248(1), L327(1), N346(1), L472(1)
Oligoplites altus N387(1)
Oligoplites mundus L53(6), N283(2), H302(1), N308(1), L396(1)
Oligoplites refulgens N49(4), L275(3), L291(2), L295(21), N301(3), L303(2), N307(4), L318(4), N366(1)
Oligoplites sp. L97(1), N170(3), S303(2), S321(1), L380(11),
Selar crumenophthalmus N84(2), S120(1), L181(1), L210(11), M227(2), H303(4), S305(9), H310(1), S312(1), S313(2), L325(1), L335(2), L336(3), L339(6), L341(1)
Selene brevoorti N49(2), N114(2), N115(1), N117(2), S153(1), S205(4), S213(7), S231(3), S234(2), S239(3), N285(2), N289(1), N299(1), S305(1), N387(1), N388(2)
Selene oerstedi N308(1)
Selene sp. S224(2)
Seriola colburni N96(1)
Seriola dorsalis N49(1)
Seriola sp. S367(1)
Seriolella crassus N395(1), N444(1), N463(4), N464(1)
Seriolella sp. L141(1)
Trachinotus kennedyi N65(1)
Trachinotus paitensis N61(1), H170(4), N76(1), L139(2), N96(3), L383(1)
Trachinotus rhodopus N65(2), L108(1), L118(2), N96(2), L320(3), L322(1)

TABLE 2—Continued

List of Specimens Collected, February 1952 to May 1959

Carrangidae—Jacks—Continued

Trachinotus sp. L53(1), L100(2), S216(1), L246(2), L284(5), L305(2), L310(1), L314(4), L386(1), L395(1)

Trachurus murphyi N354(1), N395(1), N454(1), N457(10), N459(1)

Trachurus symmetricus L269(1)

Vomer declivifrons N117(8), H121(1), L177(1), L180(1), L181(1), S215(6), S271(1), N299(1), N300(2), N413(2)

Carangids, S164(4), S259(1), L260(1), L338(1)

Stromateidae—Harvestfishes

Cubiceps sp. L154(1), S271(5), L276(1), S328(3)

Nomeus gronowi L107(1), L265(1), L269(1)

Palometa palometa N285(1)

Palometa simillima N7(1), N24(4), N25(1), N30(1), N35(5), N38(1)

Palometa sp. N50(2), N114(4)

Stromateids S261(10), N409(1)

Bramidae—Pomfrets

Brama rayi S259(1)

Coryphaenidae—Dolphins

Coryphaena equisetis L100(3), L102(3), L109(2), L126(1), L127(1), L128(9), L129(1), L131(1), L137(2), L139(3), L140(2), L148(8), H150(1), L155(4), L158(2), L175(2), L176(1), S188(1), L200(8), L207(2), L219(1), L225(2), L228(1), L229(1), L230(4), L236(10), L238(3), L247(1), L258(2), L262(8), L265(2), L269(1), L270(1), L273(2), L276(10), L286(1), L303(1), L325(2), L341(2)

Coryphaena hippurus H66(1), L108(1), L133(5), L138(1), L158(3), S190(1), N96(1), L203(1), L218(1), S220(1), L233(1), M235(1), L236(1), L246(4), L249(1), L260(2), L263(1), L266(1), L303(1), H379(1), H406(2), H468(1)

Coryphaena sp. L210(1), S272(1), L334(8), L364(2)

Echeneidae—Remoras

Phtheirichthys lineatus L158(3), M369(1)

Remilegia australis N36(1)

Remora remora M136(1), M143(1), M215(1), M326(1), M330(1), M348(1), S378(1), M384(2)

Echeneid H40(1)

Scombridae—Mackerels

Scomber diego N7(1), N24(1), N25(2), N47(1), N48(1), N56(2), N74(1), N111(1)

Scomber peruanus N354(6), N355(2), L365(1), N431(1), N440(29)

Cybiidae—Spanish Mackerels

Sarda chiliensis N398(1), N431(5), N458(1), N459(1), N460(1), N467(1)

Sarda lineolata L94(2), L95(7), L97(1)

Sarda sp. S239(4), N463(1)

Scomberomorus concolor N23(6)

Scomberomorus sierra N28(1), N42(8), N50(1), L53(5), L59(5), N71(1), H86(2), H113(2), N117(4), H183(1), S208(1), L284(1), N294(1), L303(12), H310(1), L380(1), N390(1), N392(8), N398(1)

Katsuwonidae—Skipjacks

Auxis thazard H83(2), H93(1), H143(2), H374(2)

Auxis sp. L97(15), L100(2), S101(1), L102(48), L104(4), L105(35), L106(1), L108(14), L122(1), S123(1), L126(5), L128(83), L131(13), L132(1), L133(28), L142(73), L148(28), L154(39), L155(1), L156(3), L157(3), S163(3), L168(30), S174(2), L175(5), L178(3), L182(5), S188(1), S190(1), L193(1), L199(1), L200(12), L201(17), S205(6), L207(8), S209(1), L210(90), L214(17), L219(9), L223(8), S224(2), L225(1), L226(2), L228(5), L229(2), L230(31), S231(18), L233(1), S234(2), L235(600), L236(13), L237(1), S239(6), S240(5), L243(2), L244(1), S245(4), M245(4), L246(871), L247(5), L249(6), S257(2), L258(4), L260(18), L262(500+), L263(1), L265(7), L266(28), L267(37), L270(7), S271(2), S273(11), L276(1), S282(2), L286(42), L293(1), L305(6), S313(5), L314(50), L316(1), S317(1), L327(1), L329(4), L342(4), S345(1), S353(1), L372(1), L375(4), L376(9), L382(17), L383(1), L386(10)

Euthynnus lineatus H135(1), L207(5), L260(1), S312(1), S313(3), S315(1), H333(1), L339(1)

TABLE 2—Continued

List of Specimens Collected, February 1952 to May 1959

Thunnidae—Tunas
Thunnus albacares H332(2), H349(1)
Thunnus obesus H351(1)
Tuna-like larvae L104(1), L105(8), L126(1), L193(2)
Gempylidae—Snake Mackerels
Gempylus serpens L276(1), S277(2)
Nealotus tripes S271(1)
Gempylids S345(4)
Lepidopidae—Scabbardfishes
Benthodesmus tenuis S393(1)
Lepidopus xantusi S259(1), S373(2)
Trichiuridae—Cutlassfishes
Trichiurus nitens N22(1), N27(1), N50(1), N117(1), S256(1), S259(3), N299(1), N398(3), N433(2), N435(3)
Istiophoridae—Sailfishes
Istiophorus greyi L210(5), L262(1)
Lutjanidae—Snappers
Lutjanus aratus N323(1)
Lutjanus argentiventris N88(1), L281(1), H292(2)
Lutjanus guttatus N173(1)
Lutjanus jordani M341(7)
Lutjanus peru N111(2)
Lutjanus viridis H147(1)
Lutjanids L156(2), L303(10), L350(2)
Xenichthyidae—Salemas
Xenichthys rupestris L396(2)
Xenichthys xanti N84(1), N116(2), N173(2), L177(1)
Xenocys jessiae N357(6)
Haemulidae—Grunts
Anisotremus scapularis N355(2), H356(1), N404(1)
Anisotremus sp. N301(1)
Brachydeuterus axillaris N54(1)
Brachydeuterus leuciscus L180(2), N300(1), N301(11), N392(2)
Brachydeuterus nitidus N308(1), N309(1)
Brachydeuterus panamensis N21(2)
Brachydeuterus sp. N111(6), N114(2)
Conodon serrifer N49(1), N388(3)
Lythrulon flaviguttatum N65(1)
Orthopristis cantharinus N354(2)
Orthopristis chalceus N49(1), N114(19), N301(2)
Orthopristis lethopristis N355(1)
Orthopristis reddingi N62(2)
Orthostoechus maculicauda N84(4)
Paraconodon dovii H162(2)
Sciaenidae—Croakers
Bairdiella ensifera N301(2), N308(1)
Bairdiella icistius N17(1)
Cynoscion analis N398(2), N433(1)
Cynoscion parvipinnis N21(1), H40(6), N58(4), N61(2), N65(1)
Cynoscion phoxocephalus N113(2), N294(4)
Cynoscion reticulatus N17(1), N301(1)
Cynoscion stolzmanni N28(1)
Cynoscion xanthulus N111(1)
Elattarchus archidium N113(1), N116(3), N117(2)
Genyonemus lineatus N6(3), N7(1), N24(13), N25(5), N37(4), N45(1), N55(3)
Isopisthus remifer N49(3), N294(1), N300(1)
Larimus acclivis N309(1)
Larimus argenteus N308(1)
Larimus effulgens N49(2)
Menticirrhus cokeri N409(1), N433(1), N435(8), N449(1), N451(1)
Menticirrhus nasus N301(1), N308(1)
Menticirrhus panamensis N301(1)
Menticirrhus undulatus N28(1), H40(1)
Micropogon ectenes N17(5), N21(3), N58(2)
Nebris occidentalis N300(3)
Odontoscion australis N392(1)
Ophioscion scierus N300(1), N309(1)
Ophioscion strabo N301(1)
Paralonchurus dumerili N301(1), N308(2)
Paralonchurus rathbuni N49(6)
Sciaena deliciosa N433(14), N435(2), H446(2), N451(2)
Seriphus politus N7(2), N9(6), N25(2), N42(1), N45(2)
Stellifer ericymba N294(1), N299(2)
Stellifer furthi N49(1), N299(1), N300(1), N301(2), N308(7), N387(4)
Stellifer illecebrosus N49(1), N299(1), N301(1)
Stellifer oscitans N50(2), N294(2), N308(3)
Stellifer pizarroensis N463(1)
Stellifer zestocarus N294(5), N299(1), N300(2)
Stellifer sp. L284(10), N444(41)
Umbrina sinaloae N84(4)
Umbrina xanti L396(1)
Sciaenids N442(1), L445(2)
Branchiostegidae—Blanquillos
Caulolatilus princeps H16(1), N355(1)
Embiotocidae—Viviparous Perches
Phanerodon furcatus N7(1)
Pomacentridae—Damselfishes
Abudefduf troschelii N92(3), L104(5), L108(1), L137(4), L139(2), L219(1), L236(1), L343(1), N358(2), N454(1)

TABLE 2—Continued

List of Specimens Collected, February 1952 to May 1959

Pomacentridae—Damselfishes—Cont.
Abudefduf sp. L105(21)
Chromis atrilobatus N92(2), L100(1), L103(2), L104(4), L105(8), L108(2), L156(1), L158(3), L159(14), L223(13), L247(1), L263(7), L273(1), S282(11), L286(1), L303(18), L310(1), S313(5), L314(2), L316(1), L318(5), L324(2), L325(2), L327(2), L331(4), L336(7), L339(2), L350(5), L364(2)
Nexilosus latifrons H403(2)
Pomacentrus rectifraenum N90(1), N92(1), L100(2), L104(4), L105(8), L106(1), L210(1), N358(4)
Pomacentrus sp. L156(1), L168(1), L265(7), L269(8), L270(5), L276(3), L286(7), L314(1), L318(7), L324(1), L336(4), L350(8)
Pomacentrids L102(4), L108(1), L141(2), L175(7), L219(2), L230(2), L235(15), L236(5), L246(3), L263(5), L266(2), L268(8), N290(1), L291(1), L293(2), L303(18), L305(3), S305(1), L310(4), L320(4), L322(1), N323(17), L341(2), L343(1), L344(2), L377(1), N404(5), N431(2), N460(1)

Labridae—Wrasses
Bodianus eclancheri H403(1)
Halichoeres nicholsi N358(1)
Pseudojulis notospilus N89(2), N90(1)
Pimelometopon pulchrum H16(1)

Chaetodontidae—Butterflyfishes
Chaetodon humeralis L230(1), S271(1)
Chaetodon nigrirostris L314(1)
Chaetodon sp. S124(1), S192(2), S212(1), S317(1)
Holacanthus passer N91(1), H405(1)
Pomacanthus zonipectus N65(2)
Chaetodontid S245(1)

Kyphosidae—Rudderfishes
Hermosilla azurea N35(1)
Kyphosus analogus N85(2), M227(1), N232(1)
Kyphosus elegans N85(1), N232(1)
Kyphosus lutescens H147(1)
Sectator ocyurus M250(2), M253(4)

Ephippidae—Spadefishes
Chaetodipterus zonatus N300(1)

Cheilodactylidae—Stonefishes
Cheilodactylus variegatus L462(2)
Cheilodactylus sp. N431(1), N453(5), N454(3), L456(1), N461(11), N463(2), L464(2), M465(6)

Scorpaenidae—Rockfishes
Scorpaena mystes N92(1)
Scorpaena sp. M160(1)
Sebastodes sp. N1(1)
Scorpaenids H32(2), S205(39), L223(1), S239(4), S313(6)

Oplegnathidae—Parrotfishes
Oplegnathus insignis N404(2), H405(3)

Triglidae—Gurnards
Prionotus horrens N288(1)
Prionotus quiescens N111(1), N389(1), N410(2)
Prionotus ruscarius L181(1)
Prionotus sp. N404(1)
Triglid N389(1)

Fistulariidae—Cornetfishes
Fistularia corneta L121(2), S220(2)
Fistularia sp. M19(1), N77(3), S192(7), S215(1), S259(2), S261(1), S271(1), L341(4), L377(1)

Syngnathidae—Pipefishes
Hippocampus sp. S192(1)
Syngnathus acicularis L395(3), L432(1), L448(7)
Syngnathus sp. N18(1), S164(1), S315(1), L320(1), N460(3)
Syngnathid S321(1)

Gobiidae—Gobies
Bollmannia ocellata N17(1)
Bollmannia sp. N22(8)
Gobiids N76(1), N299(1)

Dactyloscopidae—Sand Stargazers
Dactyloscopids L141(2)

Uranoscopidae—Stargazers
Astroscopus zephyreus N42(1), L59(12), N289(1)
Kathetostoma averruncus S257(3), S271(1)

Callionymidae—Dragonets
Callionymus atrilabiatus S259(3), S264(2), S274(3), L427(1)

Batrachoididae—Toadfishes
Porichthys myriaster N62(1)

Gobiesocidae—Clingfishes
Gobiesox canidens L141(5)
Gobiesox rhessodon H40(1)
Gobiesocids L105(1), M160(1), N404(1)

Clinidae—Klipfishes
Labrisomus philippii N404(4)
Labrisomus xanti N89(2), N91(1)
Labrisomus sp. L141(1)
Heterostichus rostratus N38(1)
Clinids L141(1), M160(1)

Blenniidae—Blennies
Hypsoblennius brevipinnis M227(1)
Hypsoblennius sp. N4 (1), N37(1), N63(1), S261(1), L263(3),

TABLE 2—Continued

List of Specimens Collected, February 1952 to May 1959

Blenniidae—Blennies—Continued
Hypsoblennius sp.—continued
L268(1), L291(1), L310(1), L318(3), L320(2), L322(2), N323(2), L341(3), N424(1), N460(2)
"Ophioblennius" mazorkae L401(2), N442(1), L448(4)
Ophioblennius steindachneri N90(1), L103(3), L104(9), L106(10) L108(1), L122(4), L126(1), L158(1), S209(1), L223(2), L247(2), S261(1), L263(1), L276(5), L303(8), L310(1), L318(3), L320(5), L322(1), L325(1), L336(1), L341(11), L342(30), L344(30), S345(4), L350(21), N358(1)
Ophioblennius sp. L146(19), S271(2)
Runula azalea N92(1), L303(1), L318(1), N358(1), L402(3),
Scartichthys gigas N463(1), L464(7), M465(7), L469(1)
Scartichthys sp. L141(12), L402(1), N431(6), N453(1), N460(2), L466(5), L472(2)
Blenniids L102(1), L104(1), L105(24), L106(1), S304(1), S305(1), L397(2), N417(1), L471(1)

Brotulidae—Brotulids
Brotula clarkae S259(3), S271(2), S274(1)

Ophidiidae—Cusk Eels
Lepophidium sp. N308(1)

Acanthuridae—Surgeonfishes
Prionurus punctatus N89(1), N92(1)

Balistidae—Triggerfishes
Alutera scripta S212(1)
Balistes polylepis H159(1)
Balistes sp. L53(1), L121(1), S211(1), S312(1), S313(7), L341(1)
Canthidermis adspersus L186(1), M189(1), M227(1), N248(1), L334(2), L339(1), N346(2)
Balistids S124(2), S164(1), S192(1), S224(1), L236(1), S245(1), S317(3), L341(4)

Tetraodontidae—Puffers
Arothron setosus N87(1), N89(1), N91(2), N92(1)
Lagocephalus lagocephalus S151(1), S178(1), S217(1)
Sphaeroides annulatus N17(3), N37(1), N65(2), N76(1), H356(1), N392(1)
Sphaeroides furthii N309(2)
Sphaeroides lobatus L121(4), N392(1)
Sphaeroides sp. L268(1), N294(1), N299(5), S313(11)
Tetraodontids N21(2), N27(1), L105(1), S119(1), L171(1), S273(2), S274(1), N299(1), L324(1), L397(1)

Diodontidae—Porcupinefishes
Chilomycterus affinis N354(1)
Diodon hystrix L59(1), N65(1), L162(1), H202(1), L273(1)
Diodon sp. S212(1)

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MASS MORTALITY OF MARINE ORGANISMS ATTRIBUTED TO THE "RED TIDE" IN SOUTHERN CALIFORNIA[1]

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Mass mortality of marine organisms following dinoflagellate blooms has been summarized recently by Brongersma-Sanders (1957). Mortality has been attributed directly to accumulation of toxic material in the body or indirectly to dissolved-oxygen depletion. An extensive bloom of *Gonyaulax polyedra* Stein occurred off southern California, especially in some protected harbors such as Alamitos Bay (Figure 1), from mid-September through mid-November 1962. Red tides occur to some extent every year but this was the most extensive one I have observed in the past 11 years.

Fish and shellfish deaths were reported from these waters in 1945 (Sommer and Clark, 1946), but these involved larger offshore animals. The causative organism of this red tide was not ascertained. Stohler (1959) was present during a red tide caused by *G. polyedra* at Estero de Punta Banda, Baja California in June 1958. He observed many sipunculid worms, *Sipunculus nudus* Linnaeus, and California jackknife clams, *Tagelus californianus* (Conrad), dying. Later a group from Scripps Institution of Oceanography (in Stohler, 1959) reported many *Chione* sp. dead and only a few bean clams, *Donax gouldi* Dall, alive. Since I have made periodic quantitative samples of benthic animals and fouling organisms attached to small dock floats in Alamitos Bay since 1959 and made them just prior to the onset of the red tide in mid-September 1962, an opportunity was provided to determine which organisms would survive or be killed by a bloom of these dinoflagellates. This paper compares the fouling and benthic populations before and after the extensive red tide. The term fouling organism denotes those sessile and associated forms which attach to floats, pilings, boats, etc.

MATERIALS AND METHODS

Fouling organisms were scraped from the dock floats and placed in gallon jars. Benthic samples were taken with a size-one Hayward orange-peel bucket. The color and odor of the substrate were noted then the material was transferred to a gallon jar. Both types of collections were preserved with formalin in the field. The organisms were sorted and identified in the laboratory. Benthic samples were washed through a Tyler screen having 24 openings to the inch (0.701 mm).

Dissolved oxygen was measured at 3-foot intervals to within 6 inches of the bottom. Analysis was determined by utilizing the modified

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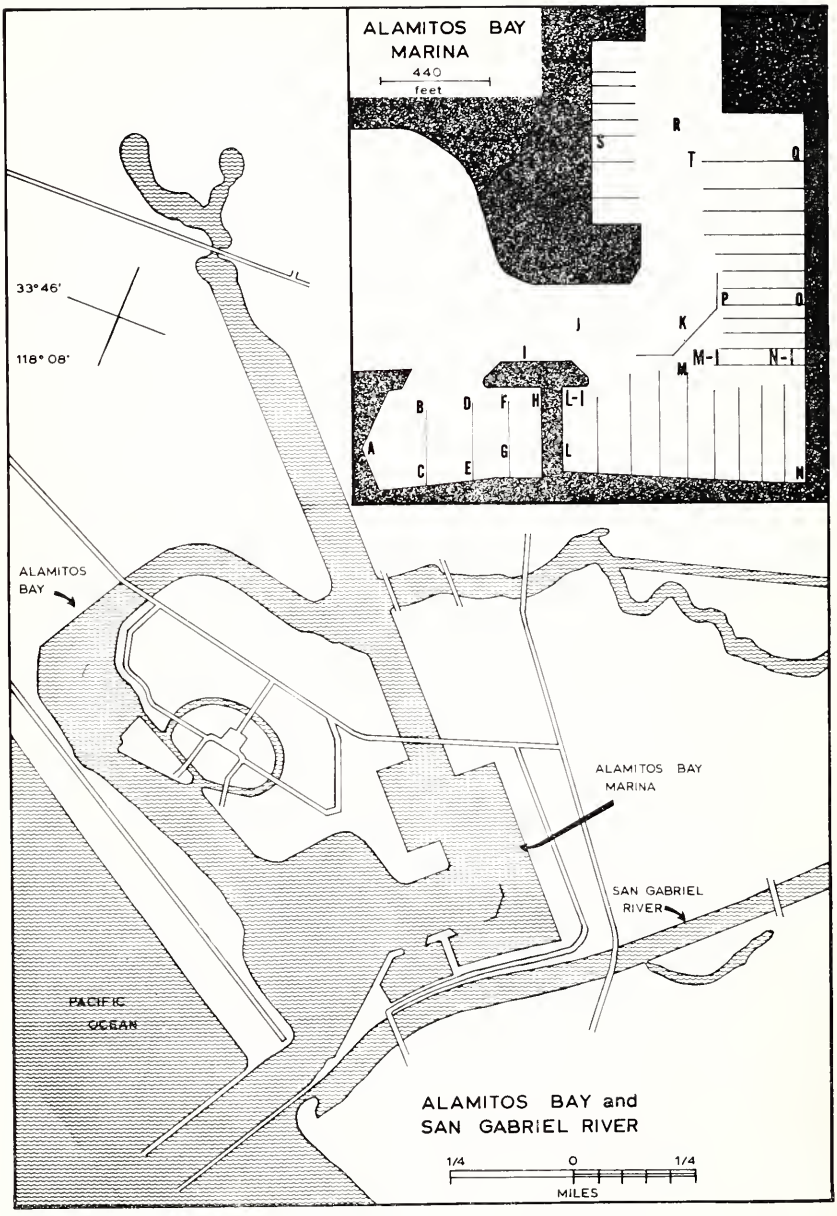

FIGURE 1. Alamitos Bay, California. The inset shows station locations in the marina.

Winkler technique (American Public Health and American Water Works Associations, 1955).

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I am indebted to the following specialists for assistance in identifying some of the organisms: Don Abbott (tunicates), J. Laurens Barnard (amphipods), E. Yale Dawson (algae), and John D. Soule (ectoprocts). The author thanks Jo Ann Bryan, Bettye Byrne, and Ronald McPeak for helping collect and sort the material.

FOULING ORGANISMS

The bay mussel, *Mytilus edulis* Linnaeus, is the principal organism of the fouling community attached to floats throughout much of the bay. Associated organisms include ectoprocts, *Bugula neritina* (Linnaeus), polychaetes, *Hydroides norvegica* (Gunnerus), tunicates, *Styela plicata* (Lesueur) and *Ciona intestinalis* (Linnaeus), and seaweed, *Ulva lobata* (Kützing) Setchell and Gardner. Additional species, especially polychaetes and amphipods, are present within this community. About 25 different species of macroscopic organisms are present during the summer (Table 1).

TABLE 1

Fouling organisms of Alamitos Bay Marina affected by the Red Tide, Fall 1962. (Species which were present on the marina floats in August 1962 but not in November 1962.)

Algae
- *Ulva lobata*
- *Polysiphonia pacifica*

Sponge, unidentified

Polychaetes
- *Halosydna johnsoni*
- *Platynereis bicanaliculata*
- *Nereis latescens*
- *Polyophthalmus pictus*

Crustaceans
- *Corophium acherusicum*
- *Elasmopus rapax*
- *Jassa falcata*
- *Caprella californica*
- *Cilicoea gilliana*

Mollusks
- *Molpalia muscosa*
- *Hiatella arctica*
- *Mytilus edulis*
- *Leptopecten latiauritus*
- nudibranchs, unidentified

Ectoprocts
- *Bugula californica*
- *B. neritina*
- *Cryptosula pallasiana*
- *Holoporella brunea*
- *Schizoporella unicornis*

Tunicates
- *Botryllus* sp.
- *Ciona intestinalis*
- *Styela plicata*

Initially, the red tide affected mussels within the marina (Figure 1, inset) in mid-October. Many shells were gaping and upon contact were slow to close. Others were dead and decaying. Fungal growths covered many of the mussels and associated sessile organisms. By early November, *M. edulis* either were dead, but still attached, or none was present on the floats. Several fouling organisms, on the floats during August 1962, were absent after the red tide in November 1962. The only living organisms observed in November were sea anemones, *Diadumc leucolena* (Verrill), polychaetes, *Hydroides norvegica*, and limpets, *Acmaea limatula* Carpenter.

The *M. edulis* community in other parts of Alamitos Bay showed evidence of at least some dead mussels and typical associated organisms were absent. Apparently the community was more affected by the red tide in areas with limited water circulation such as the inner marina. The water was redder here, indicating a higher concentration of *Gonyaulax*.

BENTHIC ANIMALS

The general effects of the red tide upon the benthic population resulted in a reduction in the number of species from September to November 1962. This decrease was from 42 to 23 species in the channel, 37 to 16 in the outer marina, and 22 to 11 in the inner marina stations (Figure 1, inset, channel stations are J, K, R; outer marina L-1, M-1, T; inner marina, L, N-1, Q).

More specifically, changes in species composition fall into four categories, those that decreased in number, increased, appeared, or were eliminated (Table 2). Fourteen species were reduced in numbers, including some of the principal ones of the community, namely polychaetes, *Capitita ambiseta* Hartman (653 to 213), *Haploscoloplos elongatus* (Johnson) (46 to 12), and *Tharyx parvus* Berkeley (29 to 7).

Eight species were more abundant following the red tide including some principal ones, namely polychaetes, *Dorvillea articulata* (Hartman) (16 to 31), *Prionospio cirrifera* Wiren (190 to 593), red ghost shrimps, *Callianassa californiensis* Dana (36 to 76), and bentnose clams, *Macoma nasuta* (Conrad) (15 to 28).

Two species were newly taken in November 1962, but only the polychaete, *Capitella capitata* (Fabricius), was present in large numbers (96). These are known pollution indicators elsewhere in southern California (Reish, 1955).

Thirty-five species were absent from the benthos in November 1962; while none of these can be considered a dominant member of the Alamitos Bay benthos, they did occur in the marina prior to the red tide. Only one specimen each was taken of 12 species in September 1962; these are not listed in Table 2.

DISCUSSION

Gonyaulax catenella Whedon and Kofoid, but not *G. polyedra*, has been reported as a carrier of the paralytic shellfish poison known to affect man and other vertebrates (Riegel *et al*, 1949). Extensive accumulation of dinoflagellates may lead to the death of mussels (Brongersma-Sanders, 1957). It is not known whether the death of *M. edulis* in Alamitos Bay Marina was caused directly by the toxic material, if

TABLE 2

Benthic Animals of Alamitos Bay Marina affected by the Red Tide, Fall 1962

	Decrease in numbers	*Increase in numbers*	*New appearance*	*Elimination*
Coelentrates-Sea anemone, unidentified			*	
Platyhelminthes-flatworms, unidentified		*		
Nemerteans, unidentified	*			
Polychaetes				
Anaitides sp.				*
Etcone paeifica				*
Eumida sanguinea				*
Ophiodromus pugettensis	*			
Nephtys caecoides	*			
Glycera americana		*		
Goniada littorea				*
Lumbrineris erecta		*		
L. minima	*			
Dorvillea articulata		*		
Haploscoloplos elongatus	*			
Nerinides acuta	*			
Polydora ligni				*
Prionospio cirrifera		*		
P. h. newportensis				*
P. malmgreni				*
P. pinnata				*
Spiophanes missionensis				*
Streblospio benedi ti	*			
Cossura candida	*			
Thaiyx pa:rus	*			
Pherusa capulata				*
Armandia bioculata	*			
Capitella capitata			*	
Capitita ambiseta	*			
Pectinaria californiensis				*
Ampharete arctica				*
Amaeana occidentalis				*
Pista alata				*
Euchone limnicola				*
Crustaceans				
Jassa falcata				*
Callianassa californiensis		*		
Pinnixa franciscana	*			
Hemigrapsus oregoniensis				*
Mollusks				
Chione californiensis				*
C. undatellum	*			
Hiatella arctica				*
Laevicardium substriatum				*
Macoma nasuta		*		
Tagelus californianus		*		
Tellina buttoni				*
Crepidula onyx				*
Olivella biplicata				*
Phoronids, unidentified	*			

such occurs, or indirectly from the depletion of dissolved oxygen in the water brought about by the death of large numbers of planktonic organisms. Dissolved oxygen measurements during this 2-month period were erratic with extremes of 2.5 to 7.3 ppm recorded by me. Walter Thomsen, California Department of Fish and Game, obtained dissolved

oxygen values as low as 0.1 ppm in Alamitos Bay Marina on October 29, 1962. Decay of the mussels' flesh and fungal growth plus subsequent dropping off of the shells probably eliminated the associated organisms except some of the independently attached species noted above. Accumulation of dead macroscopic forms and dinoflagellates would alter the benthic environment. Sediments possessing sulfide odor are sometimes observed in the inner marina area, but black sediments with very strong sulfide odors were noted at all marina stations and traces at the channel stations. The reduction of the dissolved oxygen and the subsequent alteration of the substrate from a gray mud to a black mud possessing a sulfide odor was the probable cause of the depletion or elimination of many of the benthic species. The increase in numbers of some species and the appearance of others may be the result of the decrease or elimination of competitor species in the benthos. Previous studies (Reish, 1963) of the benthic population have shown indications of some seasonal variations but not of the magnitude encountered here.

SUMMARY

A population of fouling and benthic organisms was compared before and after a red tide water bloom of dinoflagellates, *Gonyaulax polyedra*, in the fall of 1962 in Alamitos Bay Marina, California. The organisms affected by the red tide were tabulated. *Mytilus edulis* was killed either directly by the accumulation of toxic materials in its body or indirectly by the decrease of dissolved oxygen brought about by the decomposition of dead *G. polyedra*. Changes in the benthic fauna were probably the result of the decrease in dissolved oxygen in the water and/or change in the nature of the substrate.

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EGG-CASES OF SOME ELASMOBRANCHS AND A CYCLOSTOME FROM CALIFORNIAN WATERS[1]

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INTRODUCTION

Empty egg-cases or capsules of sharks and skates, sometimes called mermaid's purses, or sailor's snuff boxes, often are found entangled in fishermen's nets, or cast on shore, particularly after storms. While usually recognized as elasmobranch egg capsules, some are so similar that it is difficult to identify them with individual species, particularly among the skates. Detailed and concise descriptions of skate egg-cases, including keys to species from European waters (Clark, 1922), the Atlantic coast of Canada and the United States (Vladykov, 1936), and Japan (Ishiyama, 1950, 1952, 1955, 1958a and b) have been published; but little attention has been paid to egg-cases of Californian species. While limited descriptions and a few illustrations are available for some, not all have been described and no key exists for their identification.

Of the oviparous elasmobranch fishes along the Californian coast, the skates, family Rajidae; cat sharks, Scyliorhinidae; horn shark, *Heterodontus francisci;* and ratfish, *Hydrolagus collici;* produce eggs in distinctive, leathery capsules. The whale shark *Rhincodon typus* Smith also lays eggs (Baughman, 1955), but none has been recovered in Californian waters. The Pacific hagfish *Polistotrema stouti,* although not an elasmobranch, also produces characteristic egg capsules.

This paper provides a simple key based on measurements and prominent external characteristics for identifying the egg-cases of most oviparous elasmobranchs found in California. The capsule (Figure 7) originally described as belonging to *R. trachura* by Follett (1952) may prove to be *R. microtrachys* (Carl L. Hubbs, pers. corres.). Photographs and descriptions are included for each egg-case, several of which are described for the first time. An unidentified capsule, believed to be from a rajid, is included as is the egg-case of the Pacific hagfish.

TYPES OF EGG-CASES

In elasmobranchs, two types of egg-cases are formed: the permanent (of oviparous species) and the temporary (of ovoviviparous forms). In the permanent type, such as the skates and cat sharks, the young undergo development completely within the shell and emerge in adult form. Among Californian rajids, the usual number of embryos per egg-case is one, except for *R. binoculata* which may have as many as

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seven. The length of time for hatching is not accurately known, but for European species is believed to range from 4 to about 15 months, depending on water temperatures (Clark, 1928). Californian species probably require similar periods of time for development.

A temporary shell is formed by some elasmobranchs such as soupfin sharks, *Galeorhinus zyopterus* (Figure 1), and the spiny dogfish, *Squalus acanthias*. The young are encased only until their external gills begin to be absorbed. At this stage, the shell ruptures and the young complete their development within the uterus. They are born alive and

FIGURE 1. Temporary shell around egg of soupfin shark.—*Drawn by G. Bakker, 1949.*

the shell is either resorbed or sloughed. In spiny dogfish, the discarded shell consists of a long, thin-walled tube, clear amber in color; each shell contains from one to four eggs. The guitarfishes, *Rhinobatos* spp., produce similar shells, which may be found rolled up in the mother's uterus after birth of the young.

Skate Egg-cases

Skate egg-cases (Figures 2-8) are composed of a keratin-like substance and are generally rectangular or boxlike, with prominent hornlike processes on each corner. The horns vary from short and broad to long and whiplike, depending upon species, and one pair is usually longer than the other. Generally the posterior horns are slightly longer than the anterior. The anterior end of the case is more or less straight between the horns and is tightly fused. The posterior end, from which the embryo emerges, is slightly convex and loosely closed. The lateral edges of the capsules are usually sharply keeled for their entire length, including the horns. The texture is leathery and the color ranges from a light tan, when first deposited, to a dark brown or black after exposure to sea water. Ventral surfaces are usually flat to slightly convex, most dorsal surfaces are considerably arched.

According to Ishiyama (1958a), the egg capsules of Japanese skates are usually covered, immediately after extrusion, with a tight-fitting, felt-like mass of fibers, which is gradually reduced on exposure to the sea. The position of attachment of the fiber mass is characteristic of some species of Californian skates.

The inner and outer walls of the capsules may reveal different characteristics according to the species. Ishiyama (1958a) utilized these characteristics to distinguish capsules of Japanese rajids which are quite similar in external appearance.

While the egg-cases of Californian skates are generally similar in shape, they usually can be separated by length differences, measured along the longitudinal axis of the shell excluding the horns, and greatest width exclusive of the attachment fibers. Where there is some overlap in measurements, they can be separated by other key characters, such as surface texture, position of attachment fibers, etc.

Occasionally a skate egg-case is found with a band of shell material extending between the posterior horns and separated from the body of the case by a narrow slot. This had led to speculation as to whether such cases might represent an unknown species. Breder and Nichols (1937) reported a similar structure on several cases laid in an aquarium by an Atlantic skate, *Raja eglanteria*. This was at first thought characteristic for the species, but a second female of the same species, also in an aquarium, laid eggs without this structure (Breder and Atz, 1938). Similar connecting bands have been noticed on capsules of several Californian skates, particularly those of *R. inornata* and *R. binoculata*. Apparently these structures have no specific significance.

Cat Shark Egg-cases

The three species of cat sharks living along the Californian coast lay eggs (Figures 9-11) in distinctive vase-shaped capsules. The case of the brown cat shark, *Apristurus brunneus* Gilbert, was described by De Lacy and Chapman (1935); Edwards (1920), and Daniel (1928), described and illustrated egg-cases of the California swell shark, *Cephaloscyllium ventriosum* (Jordan and Gilbert). The egg-case of the filetail cat shark, *Parmaturus xaniurus* (Gilbert), is described and illustrated for the first time in this paper.

Cat shark egg-cases, though roughly rectangular, are rounder and slenderer than those of the skates, being shaped more like small, compressed vases. The horns are not as prominent. A characteristic keel extends along each lateral edge for the entire length of the capsule and is prolonged into a long, slender tendril at each corner of the case. The structure of this keeled ridge and the long tendrils help distinguish cat shark capsules from those of skates. The tendrils at each end are often several times longer than the capsule and are usually tightly coiled.

Other Species

Capsules of the horn shark, the ratfish, and the Pacific hagfish (Figures 12-14) are unique and bear no resemblance to those of skates or cat sharks. Each has its own characteristic form and each is represented in California by only one species.

FIGURE 2.—*Photograph by D. H. Fry, Jr., 1950.*

BIG SKATE

Raja binoculata Girard

R. binoculata produces the largest egg-case of any skate in California, and probably the largest of any species of *Raja* in the world. Sizes for 20 specimens measured by De Lacy and Chapman (1935) ranged from 265 to 305 mm total length, and from 110 to 140 mm in least width.

Although the capsules usually can be recognized by their large size alone, they differ in several respects from those of other skates. The lateral edges are roughly parallel at the posterior end, remain so for about half of their length, but become moderately concave near the middle of the case. All four horns are blunt, short, and broad; the posterior pair is longest. The posterior margin of the case between the horns is nearly straight and the anterior end is slightly concave. The ventral surface is relatively flat; the dorsal surface is highly arched at the posterior end, gradually flattening toward the anterior end. Two prominent ridges, originating near the middle of the arched dorsal surface, extend forward, roughly parallel, for about half of their length, then flare outward to the edge of the egg-case, and continue onto the outer edge of the anterior horns. The anterior margin extends as a broad, flat connection between the horns almost to their tips, so the case appears to lack anterior horns.

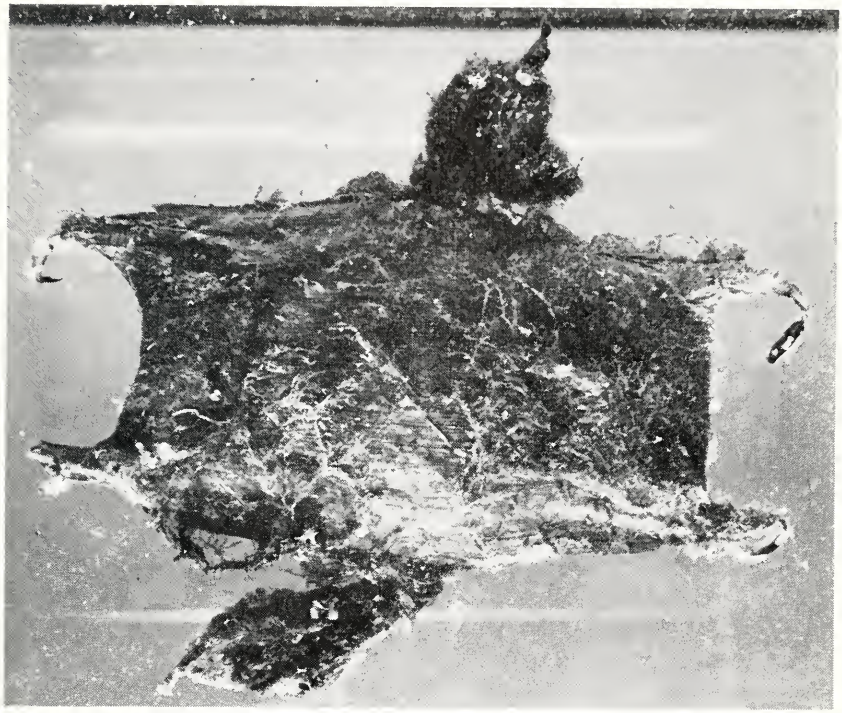

FIGURE 3.—*Photograph by D. H. Fry, Jr., 1950.*

LONGNOSE SKATE
Raja rhina Jordan and Gilbert

The egg-case of *R. rhina* is rectangular, about twice as long as wide, and bears a pair of short, slender horns at each corner. The anterior horns are longest and the edge of the capsule between them is slightly concave; the capsule edge between the posterior horns is almost straight. Attachment threads arise in a mass along each moderately convex lateral edge. The threads are almost completely worn away from some capsules, while in others (presumably younger) short, fine threads almost completely cover the case. The attachment fibers are greenish and the case itself is usually dark-brown or black. The egg-case of *R. rhina* closely resembles that of *R. inornata* (Figure 4), but its surface is rough rather than smooth.

De Lacy and Chapman (1935) measured 41 cases which ranged in least length from 94 to 130 mm and in greatest width from 54 to 77 mm.

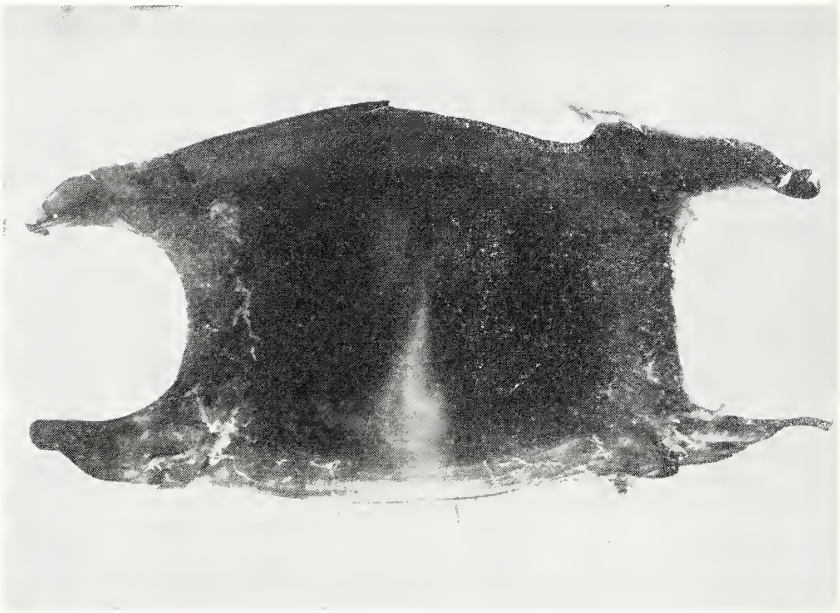

FIGURE 4.—*Photograph by D. H. Fry, Jr., 1950.*

CALIFORNIA SKATE

Raja inornata Jordan and Gilbert

The egg capsules of *R. inornata* have not been described previously. The horns at the anterior end of the rectangular case are longer and straighter than those at the posterior end, though in older, worn specimens, all may be approximately the same length. The anterior edge between the horns is concave; the posterior edge, almost straight. Attachment fibers occur at both the anterior and posterior edges between the horns. The surface texture is smooth, because the longitudinal fibers are small and close together. The characteristic smooth surface helps distinguish this capsule from that of *R. rhina*, the longnose skate (Figure 3). The color varies from the pale olive-green of recently-laid eggs to dark brown or black in the more mature cases.

Fifty egg-cases measured by the author ranged in least length from 70 to 85 mm, averaging 76 mm; in greatest width, from 65 to 76 mm, averaging 71 mm. Only one egg is deposited in each case. Since embryos were found in all stages of development, this skate appears to spawn thoughout the year.

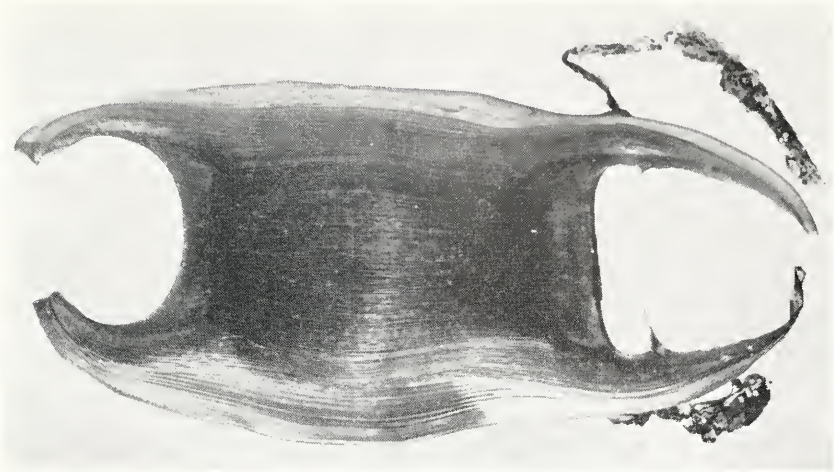

FIGURE 5.—*Photograph by D. H. Fry, Jr., 1950.*

STARRY SKATE

Raja stellulata Jordan and Gilbert

The egg-case of the starry skate has not been described before. Angular in outline with horns at the four corners, the shape is characteristic of the rajids. A pronounced, striated surface formed by tightly packed, coarse, longitudinal fibers differentiates this capsule from those of the other Californian skates. These prominent fibers give the case a distinctive roughened texture. The anterior horns are longer than the posterior ones and taper to flattened points. The edge between the anterior horns is almost straight; that between the posterior horns is deeply convex. Attachment fibers are sparse, with a few strands fastened to the bases of the anterior horns at the lateral edges. The capsule's surfaces are free of the usual mass of attachment threads that cover large areas on some of the other species. Whether the absence of these threads is characteristic is unknown. Neither the time of egg laying nor the length of time necessary for hatching is known. Four specimens measured by the author ranged from 71 to 78 mm in least length and from 55 to 70 mm in greatest width.

FIGURE 6.—*Photograph by D. H. Fry, Jr., 1950.*

SANDPAPER SKATE

Breviraja kincaidi (Garman)

This skate produces the smallest egg-cases of any Californian rajid. Nine egg-cases measured by the author ranged in length from 49 to 59 mm and in width from 40 to 50 mm; this is the first time the capsule has been described and illustrated.

Similar in shape to those of the other skates, the sandpaper skate's egg-case can be recognized primarily by its small size and by the angles made by the anterior horns. These horns, bend toward each other at an acute angle on emerging from the body of the capsule, extend almost straight, and cross near their extremities. Attachment fibers arise along the edges of the prominent lateral keels. The surface is moderately roughened due to the rather coarse longitudinal fibers. Time for hatching is not known but is believed to be from 6 to 9 months.

FIGURE 7.—*Photograph by D. H. Fry, Jr., 1950.*

ROUGHTAIL SKATE
Raja trachura Gilbert

As far as known, the only record of an egg-case (Figure 7) of this species is of one taken in a dredge off Pt. Montara, San Mateo Co., California, from 700-1,000 fathoms. The capsule contained a single small male embryo, 185 mm in total length, that Follett (1952) identified as *Raja trachura* Gilbert, the roughtail skate. Recent studies by Reizo Ishiyama and Carl L. Hubbs (pers. corres.) indicate this capsule might belong to *R. microtrachys*, a deep-sea skate hitherto known only from one adult dredged in deep water off northern Baja California.

Although measurements of this egg-case place it within the same size range as those of *R. rhina*, its unique, smooth, satin-like surface texture distinguishes it not only from the capsules of *R. rhina*, but also from the egg-cases of all other Californian skates.

As described by Follett (1952), "the egg-case appears longitudinally striate. Under low magnification each of the striae is seen to bear a dense series of translucent brownish villi, which renders the surface of the egg-case plush-like to the touch." The horns are slender, all about equal in length, gradually tapering to a point. The anterior horns curve toward each other in a broad arc, meeting with a slight overlap of the tips. The posterior horns extend from the end of the case and remain roughly parallel for their entire length. Extreme length (including horns) of this egg-case (C. A. S. #25617) is 210 mm.

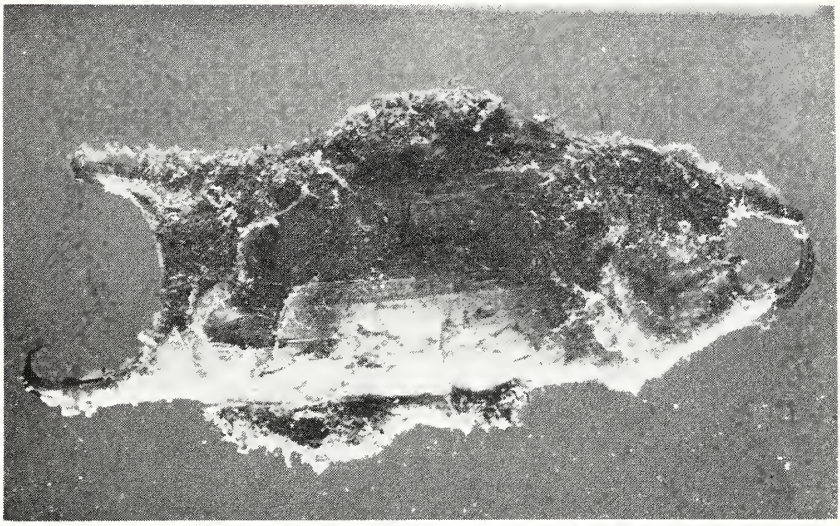

FIGURE 8.—*Photograph by D. H. Fry, Jr., 1950.*

UNIDENTIFIED SKATE

Raja sp.

This egg-case appears unlike any of the types here described. The anterior end with the short horns bent to an acute angle toward each other, compressing the end of the case between the horns into an almost circular form, is similar to that of the swell shark (Figure 11). However, the lack of a neck or constriction, the absence of rounded tendrils, the abundance of attachment fibers, and the angular form are characteristics of the skates. Length (90 mm), and width (40 mm), place it closest to the egg-case of *R. trachura*, but it lacks the velvety surface of that species. It is considerably smaller than the smallest egg-case referred to *R. rhina*, and the surface fibers are coarser.

This case is in all probability from one of the Pacific Coast skates which has not been reported from Californian waters, and whose egg-case has not been described. Carl L. Hubbs and W. I. Follett (pers. corres.) have suggested that it may be a malformed case of *R. rhina*.

The case was collected by the author north of Santa Cruz, California, in 84 fathoms during an exploratory trawl cruise aboard the *N. B. Scofield* in 1950.

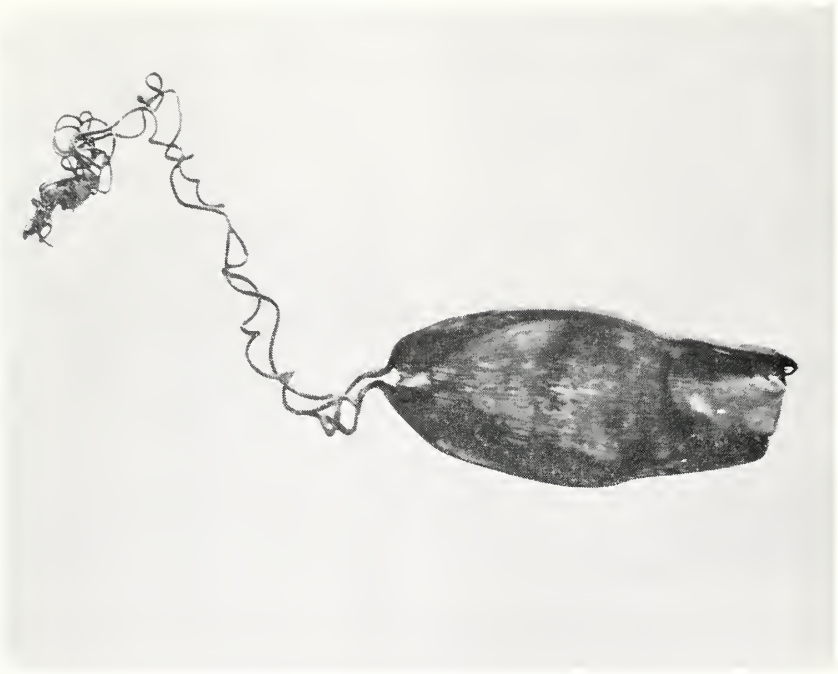

FIGURE 9.—*Photograph by D. H. Fry, Jr., 1950*

BROWN CAT SHARK

Apristurus brunneus (Gilbert)

The brown cat shark's egg-case is the smallest of any of the egg-laying Californian elasmobranchs. The main body, exclusive of the tendrils, is rounded, about 2 inches long, and approximately 0.75 inches wide. The brownish, translucent case contains a single egg or embryo. According to De Lacy and Chapman (1935), the least length, not including the tendrils, ranges from 52 to 56 mm, averaging approximately 53.8 mm, the greatest width, from 22 to 25 mm, averaging about 23.2 mm.

A slight neckline constriction about a third of the distance from the anterior end gives the case the characteristic vase shape of the family Scyliorhinidae. The anterior end is truncate, the posterior end contracted to a blunt rounded tip. A rounded flange runs along the lateral edges for the entire length and is extended both anteriorly and posteriorly into a long, coiled tendril which gradually tapers to a thin distal end.

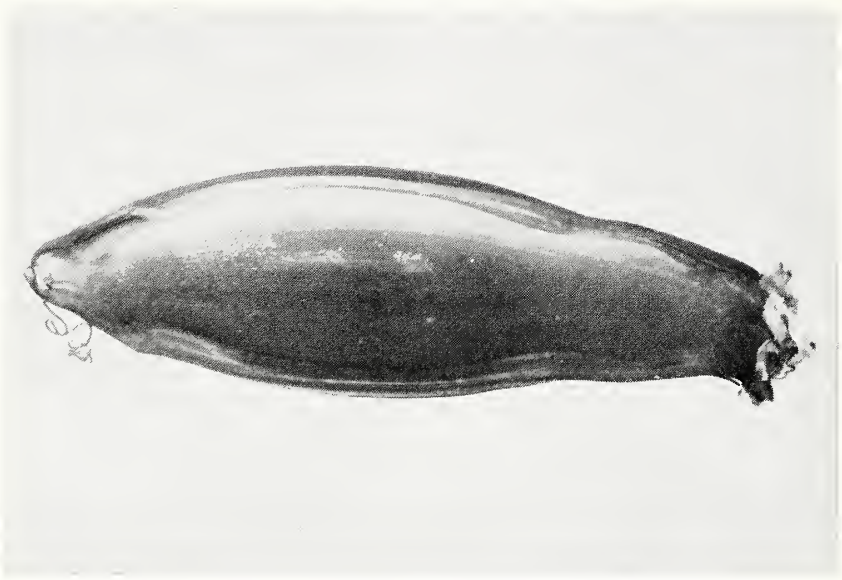

FIGURE 10.—*Photograph by D. H. Fry, Jr., 1950.*

FILETAIL CAT SHARK

Parmaturus xaniurus (Gilbert)

The filetail cat shark's egg-case is long, about 74 mm to 110 mm, and slender, from 28.5 to 36 mm, and more streamlined than those of the other cat sharks. It is widest about the middle, and tapers gently toward rounded anterior and blunt posterior ends. A slight constriction gives the case the appearance of small Greek amphora without handles. The smooth surface is light tan. Each capsule contains a single egg. The flange extending along each lateral edge is capped by a narrow (2 mm) right-angle flange, giving a "T"-like appearance in cross section. Approaching the ends of the capsule, the flanges gradually transform into the characteristic rounded tendrils which are almost thread-like, and considerably shorter than those of the other cat sharks. A small mass of attachment fibers is usually present on the blunt anterior end.

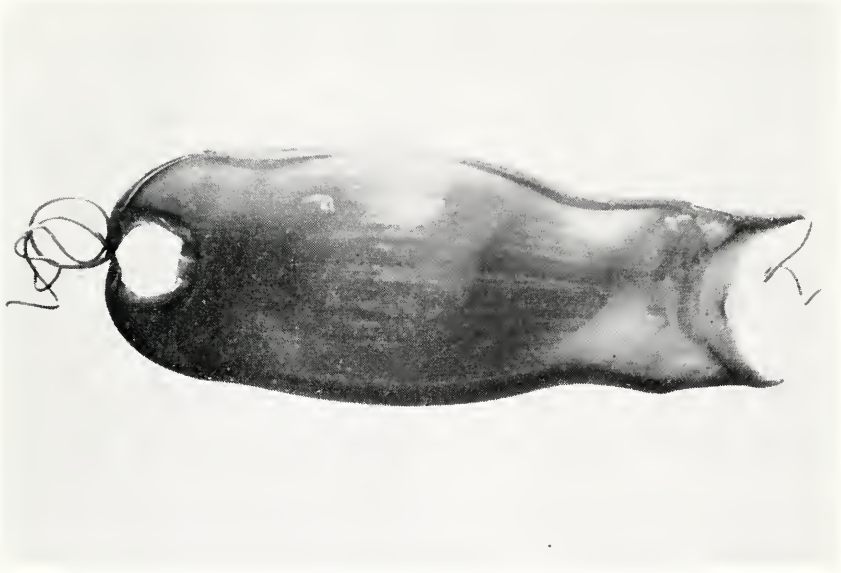

FIGURE 11.—*Photograph by D. H. Fry, Jr., 1950.*

SWELL SHARK

Cephaloscyllium uter (Jordan and Gilbert)

The swell shark produces the largest egg-case of the three Californian cat sharks. They range from about 90 to 125 mm long, and from 28 to 55 mm wide. The case is more rectangular and the tendrils are thicker than those of the two other cat sharks. At the anterior end, the short and thick horns taper to points that extend as coiled tendrils. Bending acutely toward each other, the anterior horns form an abrupt rounded end to the capsule; the area between the horns is deeply concave, almost circular. The horns at the blunt, posterior end are short, extending into relatively thick, coiled filaments (usually broken off in older specimens). The margin between the posterior horns is deeply crescentic.

A constricted neck gives the case the characteristic vase-shape of cat sharks. The capsule tapers gradually toward the posterior end after flaring out from the neck, and constricts slightly just before the anterior end, giving the lateral edges a gently undulating appearance. Freshly laid cases are light, transparent tan; the single egg or embryo can be seen inside. On exposure to sea water the case darkens but remains translucent. Length of time for hatching is not known, but Edwards (1920) found that a 43 mm embryo took 5 months to complete development and was 155 mm long when hatched.

FIGURE 12.—*Photograph by D. H. Fry, Jr., 1950.*

HORN SHARK

Heterodontus francisci (Girard)

The horn shark produces an egg capsule quite different in appearance from those of any other egg-laying elasmobranch of California. The main body of the case, about 125 mm in length, is cone-shaped. Two characteristic flanges coil in a spiral four or five times around the case, from the apex to the large, wide, posterior end. There are no tendrils on the egg of this species, although those of another member of the genus (*H. galeatus*) may have tendrils as long as 7 feet (Daniel, 1928; Smith, 1942). The case is light brown and pellucid when first laid, but after exposure to sea water becomes dark brown and leathery. The older ones become quite ragged, often with portions of the flanges missing or broken off. The capsules are laid in pairs, each containing a single egg which hatches in from 8 to 12 months (Dempster and Herald, 1961).

FIGURE 13.—*Photograph by D. H. Fry, Jr., 1950.*

RATFISH

Hydrolagus colliei (Lay and Bennett)

The unique ratfish egg-case is easily distinguished from those of the sharks and skates. It is the only non-rectangular case among the shark-like fishes of California, other than the horned shark. The main body is oval, bluntly pointed anteriorly, stretching out posteriorly into a long, narrow, laterally flattened, keel-like structure. Its overall length is about 125 mm, its greatest width about 30 mm. From the dorsal surface the capsule looks like a large, slender tadpole. A fringed flange extending along each lateral edge together with the vertical keel keeps the case directed into the water current, so as to insure an adequate circulation to the enclosed embryo. As the embryo develops it gradually fills the capsule. The head and body occupy the anterior end, and the tail, the long narrow posterior end. The case is light tan to olive-green when first laid, but gradually becomes dark brown to black on exposure to sea water. Two cases are extruded over a period of 18-20 hours, the blunt end appearing first. According to Dean (1903), development takes about a year and the young emerge from the egg-case as miniature adults.

FIGURE 14.—*Photograph by Menlo Camera Shop, 1962.*

PACIFIC HAGFISH

Polistotrema stouti (Lockington)

The Pacific hagfish, which is not an elasmobranch but belongs to the class Agnatha, the jawless fishes, produces a characteristic egg-case. Newly-laid capsules look like small, yellow cocktail sausages, about 25 mm long and 10 mm wide. They are semi-transparent with a bright yellow yolk. A slight indentation circumscribing the anterior end marks the rim of the operculum (Dean 1897). When this caplike structure separates from the main body of the capsule along the indented line, the young hagfish emerges through the opening. Each capsule contains a single embryo. By the time of hatching, which takes from 4 to 6 months (Dean 1897), the young hagfish is about twice as long as its egg-case, and is doubled into a U-shape inside the capsule.

The eggs are laid singly, but are usually in long strings attached together by minute hooks on the ends of 30 to 40 threads that form a tuft at each end of each capsule. Under the microscope these hooks look like miniature, long-stemmed mushrooms, with the caps deeply scalloped into three to six lobes. When separate capsules tend to pull apart after coming in contact, the stems of one case slip between the lobes on the cap of another effectively locking them together. In addition, a gelatinous substance surrounding the tufts acts as an adhesive entanglement.

ACKNOWLEDGMENTS

Several members of the Department of Fish and Game have been of considerable help in compiling this paper. Special thanks are due to D. H. Fry, Jr., who took all of the photographs (except that of the Pacific hagfish) and who developed a unique underwater technique for

this purpose; to John E. Fitch, for calling to my attention several obscure but important references; to H. G. Orcutt for suggestions regarding the key; and to R. L. Poole, for contributing the Pacific hagfish egg-case. W. I. Follett, California Academy of Sciences, kindly furnished the capsule of *R. trachura*, and Stanford University Natural History Museum the case of *Parmaturus xaniurus;* I am indebted particularly to Carl L. Hubbs, Scripps Institution of Oceanography, for critically reviewing the manuscript.

KEY TO EGG-CASES OF SOME ELASMOBRANCHS AND A CYCLOSTOME FROM CALIFORNIAN WATERS

This key is based primarily on differences in form, size, and surface configuration of the egg-cases. Skate and cat shark capsules, while somewhat similar, can readily be separated by difference in form: skate cases are box-shaped, those of the cat sharks are vase-shaped. Most species of skate and cat shark capsules can be distinguished by size. Where overlap in length occurs, differences in surface texture or placement of attachment fibers will separate the species.

Cases of the other elasmobranchs and the cyclostome are sufficiently individualistic to be recognized by form alone.

Capsules are measured longitudinally along the least length between the horns and the greatest width, including lateral flanges. Overall length is not measured because the horns and/or tendrils are usually broken or missing, especially on older specimens.

SECTION A

1 Case rectangular ..... Rajidae B
Case vase-shaped ..... Scyliorhinidae C
Case cone-shaped, spiral flanges Horn shark, *Heterodontus francisci* (Page 284)
Case tadpole-shaped ..... Rattish, *Hydrolagus colliei* (Page 285)
Case sausage-shaped, usually several strung together
Pacific hagfish, *Polistotrema stouti* (Page 286)

SECTION B

Rajidae egg-cases

1 Length over 250 mm ..... Big skate, *Raja binoculata* (Page 274)
Length 90-110mm 2
Length 70-85 mm 3
Length less than 50 mm ..... Sandpaper skate, *Breviraja kincaidi* (Page 278)

2(1) Velvety surface, no attachment fibers
Roughtail skate, *Raja trachura* (Page 279)
Smooth surface, attachment fibers on lateral edges
Longnose skate, *Raja rhina* (Page 275)
Coarse surface, attachment fibers abundant, covering almost entire capsule ..... Unidentified skate, *Raja* sp. (Page 280)

3(1) Rough surface, prominent longitudinal fibers
Starry skate, *Raja stellulata* (Page 277)
Smooth surface, attachment fibers at anterior end
California skate, *Raja inornata* (Page 276)

SECTION C

Scyliorhinidae egg-cases

1 Length from 70-135mm 2
Length from 50-60 mm ..... Brown cat shark, *Apristurus brunneus* (Page 281)

2(1) Lateral flanges rounded ..... Swell shark, *Cephaloscyllium ventriosum* (Page 283)
Lateral flanges T-shaped in cross section
Filetail cat shark, *Parmaturus xaniurus* (Page 282)

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AGE AND LENGTH COMPOSITION OF THE SARDINE CATCH OFF THE PACIFIC COAST OF THE UNITED STATES AND MEXICO IN 1960-61 [1]

by

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INTRODUCTION

This is the 15th report in a series on age and length composition of the catch of Pacific sardines, *Sardinops caerulcus* (Girard), off the Pacific coast of North America. These have been prepared on a seasonal basis since the 1941-42 season (Wolf and Daugherty, 1961).

We wish to acknowledge the valuable assistance given by Clark Blunt of the California Department of Fish and Game and by Makoto Kimura of the U. S. Bureau of Commercial Fisheries.

THE FISHERY

During the 1960-61 commercial season, 26,943 tons of sardines were taken by the California fishery in central and southern California. In addition the Mexican fishery off Baja California took 19,763 tons during calendar 1961 for a total commercial sardine catch of 46,706 tons.

Central California

The 1960-61 sardine season in central California (Point Arguello north to Point Arena) began on August 1, 1960, and ended on December 31, 1960. Within this period fish were landed during only three lunar months or dark-of-the-moon periods (Table 1)—"August," "September," and "October"—because a price dispute kept the fleet from fishing until August 16 and because fish became unavailable after "October." Lunar months are set in quotation marks to distinguish them from the calendar months they approximate. During "August" 1,876 tons were landed (approximating 91 percent of the season's catch from this region), during "September" 150 tons, and during "October" 37 tons. The seasonal total of 2,063 tons is small when compared with 15,418 tons and 24,614 tons taken during the 1959-60 and 1958-59

[1] Submitted for publication, June 1963.

TABLE 1

Calendar Dates of Lunar Months During 1960

Lunar month	*Lunar period*	*Dates*
"January"	497 *	December 15 (1959)-January 12
"February A"†	498	January 13-February 10
"February B"	499	February 11-March 11
"March"	500	March 12-April 10
"April"	501	April 11-May 10
"May"	502	May 11-June 8
"June"	503	June 9-July 8
"July"	504	July 9-August 6
"August"	505	August 7-September 5
"September"	506	September 6-October 5
"October"	507	October 6-November 3
"November"	508	November 4-December 3
"December"	509	December 4-January 1 (1961)

* Lunar months have been numbered serially since "November" 1919.
† Because lunar months are shorter than calendar months it is necessary to add an additional lunar month every 3 years.

seasons, and extremely small compared to the 435,000+ tons taken during the 1940-41 season.

The earliest catches during "August" were made by lampara boats operating close to the southern edge of Monterey Bay. Later in the dark some sardines were taken from around Cape San Martin and Lopez Point. During the remaining two darks, the central California catch came almost entirely from the Morro Bay area.

At the beginning of the season 28 boats were involved in the fishery. This total included 11 large purse seiners, two small purse seiners, and 15 lampara boats. The sardine fishing efforts of the latter varied directly with the immediate availability of sardines as these vessels are readily adaptable to other types of fishing. As the season progressed and sardines became less available in central California the purse-seine fleet gradually shifted to Port Hueneme in southern California. From mid-"September" until the end of the season all the purse seiners in the central California fleet spent some time fishing sardines in southern California.

The ex-vessel price of fish was $35 per ton. When trucking fish from port of landing to cannery (sometimes from southern California ports to central California canneries) was necessary, the cost of trucking was divided equally between the boat or boats involved and the cannery.

Seven canneries processed sardines in central California, one each in San Francisco and Moss Landing, and five in Monterey. These plants handled approximately 6,500 tons of fish—over two-thirds trucked from southern California.

Southern California

A total of 24,880 tons of sardines was landed in southern California (Point Arguello south to the Mexican border) during the season which began on September 1, 1960, and ended concurrently with the central California season on December 31, 1960. This tonnage was considerably under the 78,007 tons taken during 1958-59, but slightly over the 20,335

tons landed during 1959-60. During the 5 days of "August" remaining after the season began, 809 tons were landed. "September" was high with 10,779 tons taken; in "October" 7,873 tons were landed, in "November" 4,130 tons, and in "December" 1,289 tons.

Most of the southern California sardine catch came from around the Channel Islands, mainly Santa Cruz and Anacapa and to a lesser extent San Nicolas and Santa Rosa. Small amounts were taken from around Point Dume, on Santa Monica Bank, and in Santa Monica Bay which was open to bait net (small lampara) commercial fishing from October 1 to December 31 for the second successive season. Additional small amounts came from off Santa Catalina and San Clemente Islands, and from Cortez Bank. Only a few small catches came from the Newport-Huntington Beach area, south of San Pedro.

The southern California fleet consisted of 58 large purse seiners and 31 small purse seiners and lampara boats. Of these, 11 large seiners and 2 small seiners fished in central California during the early part of the season. The total California fleet was the smallest to fish sardines in over 30 years. No boats from the Pacific Northwest took part in the fishery.

The price in southern California had been set the previous July at $35 a ton but trucking charges, where necessary, were paid by the boat.

One cannery operated at Oxnard utilizing fish landed at Port Hueneme; six operated in the Los Angeles-Long Beach harbor area.

Baja California

The sardine fishery off Baja California, Mexico, is a year-round enterprise. We have divided the year into two parts, January 1 to August 31, and September 1 to December 31, so that the latter part may be compared with the southern California season. During the first part, the "interseason," 12,323 tons were landed and during the second part, the "season," 7,440 tons were landed.

The 1960 Baja California sardine fishery ranged from the U.S.-Mexican border south to about Punta Abreojos (approximately 400 miles). Sardines in commercial quantity are present in at least part of this range throughout the year. Three ports, each with one or more canneries, are located within its limits. Ensenada, located 69 miles below the border, added a cannery during 1960 for a total of six packing sardines in that city. It is the largest fishing port in Baja California, and prior to 1958 produced over 80 percent of the annual sardine pack. Since 1958, however, the sardine center of abundance has gradually shifted south so that in 1960 the Cedros Island cannery produced nearly one-half of the total Baja California sardine pack. This cannery is located almost 300 miles south of the border and the range of its vessels determines the fishery southern limit. A cannery at San Quintin Bay, about halfway between the above two ports, packs sardines only when available in the immediate vicinity of the bay.

In 1960, the Baja California fishing fleet consisted of 40 vessels that spent some part of their time fishing sardines. Thirty-one of these were generally located at Ensenada, eight at Cedros Island, and one at San Quintin. Two of the boats based at Ensenada also landed fish at Cedros

Island during part of the year. The fleet consisted of large and small purse seiners, most of them locally owned, but occasionally was augmented by American boats from San Diego and San Pedro. (The extent to which American boats contribute to the sardine catch in Mexican ports is not known.) Many of the large vessels are now equipped with refrigerated holds which allows them to fish for longer periods and at greater distances from port than previously.

The amount paid to fishermen for sardines canned in Baja California varied with their operational status. Crews under contract to canneries, fishing on cannery-owned vessels, received up to 188.75 pesos (U. S. $15.10) per metric ton (2,205 lbs.). Privately owned vessels, usually American owned and operated, received up to 410.00 pesos (U. S. $32.80) per metric ton. Though the prices quoted are the maximums paid by the canneries, the range of prices was slight so the given prices are close to the average for the year.

AGE AND LENGTH COMPOSITION

During the commercial sardine season, 1,050 fish from central California and 4,100 fish from southern California were randomly selected from the catch in lots of 50 and measured (standard length) to the nearest millimeter. When these measurements were summarized and plotted (Figure 1) two separate size groups were evident in central California, and a single size group in southern California. Lengths of fish from central California ranged from 156 to 186 mm for the smaller group, and from 206 to 264 mm for the larger group. In southern California fish ranged from 164 to 250 mm.

Approximately one-fifth of the fish sampled were randomly selected for aging. Scales from the mid-lateral region of each fish were removed, prepared, and examined for annual markings. The central California age sample of 223 fish ranged from 158 to 264 mm and contained five year-classes: 1955, 1956, 1957, 1958, 1959 (Table 2). The southern California age sample of 817 fish ranged from 174 to 246 mm and included six year-classes: 1953 and 1955 through 1959 (Table 3). The Baja California catch was not sampled during the latter half of calendar year 1960.

During the interseason, scattered samplings of sardines were made in both central and southern California. These interseason catches appear to represent a random sampling of sardines present in the fishing areas during the offseason. As during the commercial season, age compositions of interseason samples were obtained from one-fifth of the fish measured. Plots of length and age compositions of samples, summarized by lunar months for both interseason and regular season samples taken in central and southern California, are presented with similar plots of interseason samples from Baja California (Figure 2).

In central California, samples were obtained during nine consecutive lunar months ("February B" through "October"). The modal lengths of the group of larger fish showed an advance from 216 to 222 [2] mm

[2] This and subsequent mode changes cited in the text are presented as even numbers adjusted to 2 mm intervals because sardine lengths are normally tabulated this way. When these changes appear in Figure 2, they are not so precisely portrayed because of the necessity to plot the length frequency polygons on 10 mm intervals in order to present smooth curves.

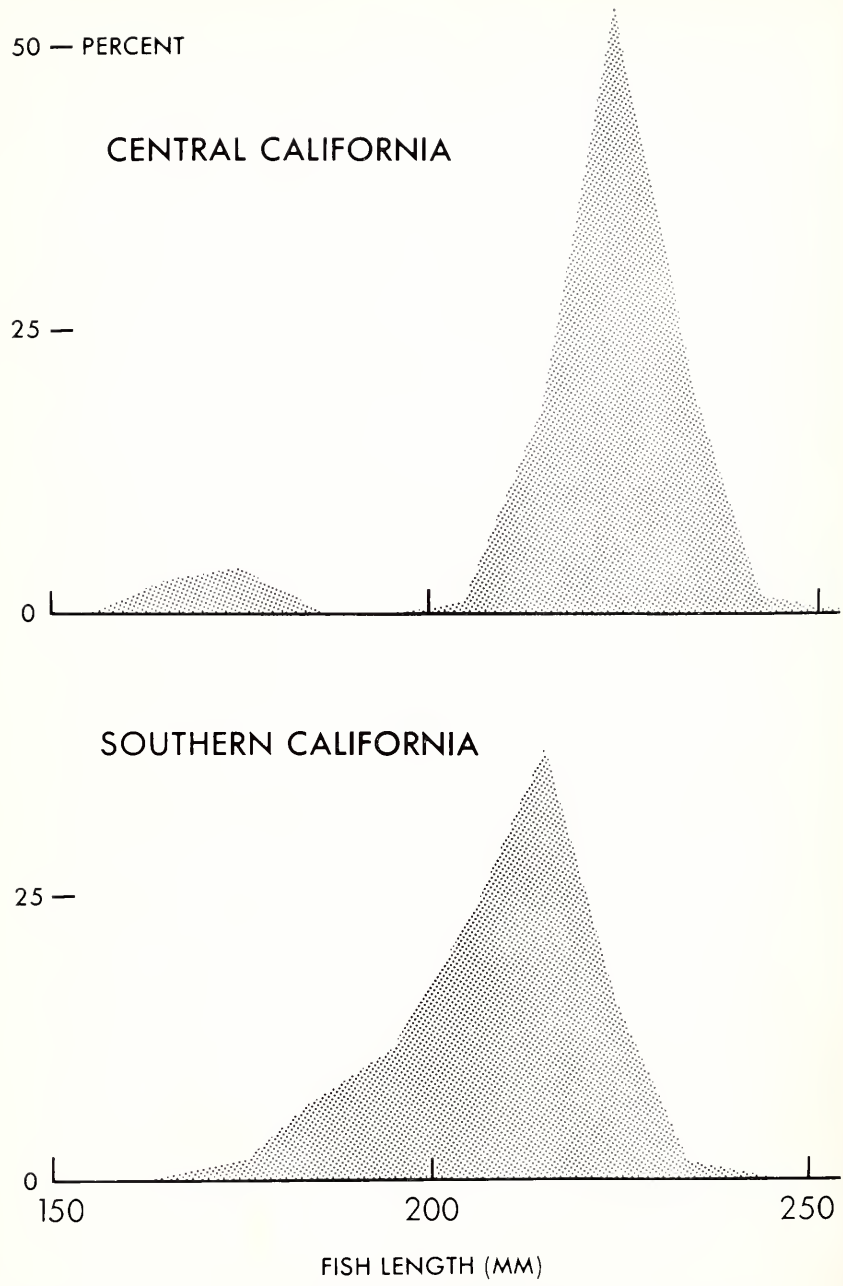

FIGURE 1. Percentage length composition of sardines sampled during the 1960-61 commercial season by region of capture. Data are plotted at 10 mm intervals.

TABLE 2

Length Composition of Year-classes in Sardine Samples from the Central California Commercial Catch, 1960-61 Season

Age	0	1	2	3	4	5	
Year-class	1960	1959	1958	1957	1956	1955	Total
Standard length mm.							
158	--	2	--	--	--	--	2
160	--	--	--	--	--	--	--
162	--	3	--	--	--	--	3
164	--	1	--	--	--	--	1
166	--	2	1	--	--	--	3
168	--	2	1	--	--	--	3
170	--	3	3	--	--	--	6
172	--	1	1	--	--	--	2
174	--	1	--	--	--	--	1
176	--	--	--	--	--	--	--
178	--	1	--	--	--	--	1
180	--	--	1	--	--	--	1
182	--	1	--	--	--	--	1
184	--	1	--	--	--	--	1
208	--	--	--	--	--	--	--
210	--	--	--	--	1	--	1
212	--	--	--	1	1	--	2
214	--	--	--	3	2	--	5
216	--	--	--	2	1	--	3
218	--	--	--	6	6	--	12
220	--	--	--	5	4	--	9
222	--	--	--	17	6	1	24
224	--	--	2	16	7	1	26
226	--	--	2	13	2	--	17
228	--	--	1	16	8	1	26
230	--	--	--	17	10	1	28
232	--	--	--	9	5	--	14
234	--	--	--	4	8	2	14
236	--	--	--	3	2	--	5
238	--	--	--	4	1	1	6
240	--	--	--	1	2	1	4
242	--	--	--	--	1	--	1
264	--	--	--	--	1	--	1
Totals	--	18	12	117	68	8	223
Mean lengths	--	169	194	226	227	231	220

TABLE 3

Length Composition of Year-classes in Sardine Samples from the Southern California Commercial Catch, 1960-61 Season

Age	0	1	2	3	4	5	6	7	
Year-class	1960	1959	1958	1957	1956	1955	1954	1953	Total
Standard length mm.									
174	--	--	2	--	--	--	--	--	2
176	--	--	--	1	--	--	--	--	1
178	--	--	1	--	--	--	--	--	1
180	--	1	2	--	--	--	--	--	3
182	--	--	6	5	--	--	--	--	11
184	--	1	11	6	--	--	--	--	18
186	--	1	6	6	--	--	--	--	13
188	--	--	3	5	--	--	--	--	8
190	--	--	6	5	1	--	--	--	12
192	--	1	7	7	1	--	--	--	16
194	--	2	9	8	--	--	--	--	19
196	--	--	6	4	--	--	--	--	10
198	--	--	11	12	1	--	--	--	24
200	--	--	12	12	5	--	--	--	29
202	--	--	11	4	5	--	--	--	20
204	--	--	10	18	--	--	--	--	28
206	--	--	11	21	2	1	--	--	35
208	--	--	13	22	7	--	--	--	42
210	--	--	8	30	12	1	--	--	51
212	--	1	15	41	10	4	--	--	71
214	--	--	8	40	15	--	--	--	63
216	--	--	8	33	14	1	--	--	56
218	--	--	2	42	18	1	--	--	63
220	--	--	8	42	20	1	--	--	71
222	--	--	2	33	16	--	--	--	51
224	--	--	1	22	14	--	--	--	37
226	--	--	3	14	10	--	--	--	27
228	--	--	--	6	5	--	--	--	11
230	--	--	1	6	5	--	--	--	12
232	--	--	--	2	2	--	--	--	4
234	--	--	--	2	1	--	--	--	3
236	--	--	--	1	1	--	--	--	2
238	--	--	--	1	--	--	--	--	1
240	--	--	--	--	--	--	--	--	--
242	--	--	--	--	--	--	--	--	--
244	--	--	--	--	--	--	--	1	1
246	--	--	--	--	--	1	--	--	1
Totals	--	7	183	451	165	10	--	1	817
Mean lengths	--	192	202	212	217	216	--	--	211

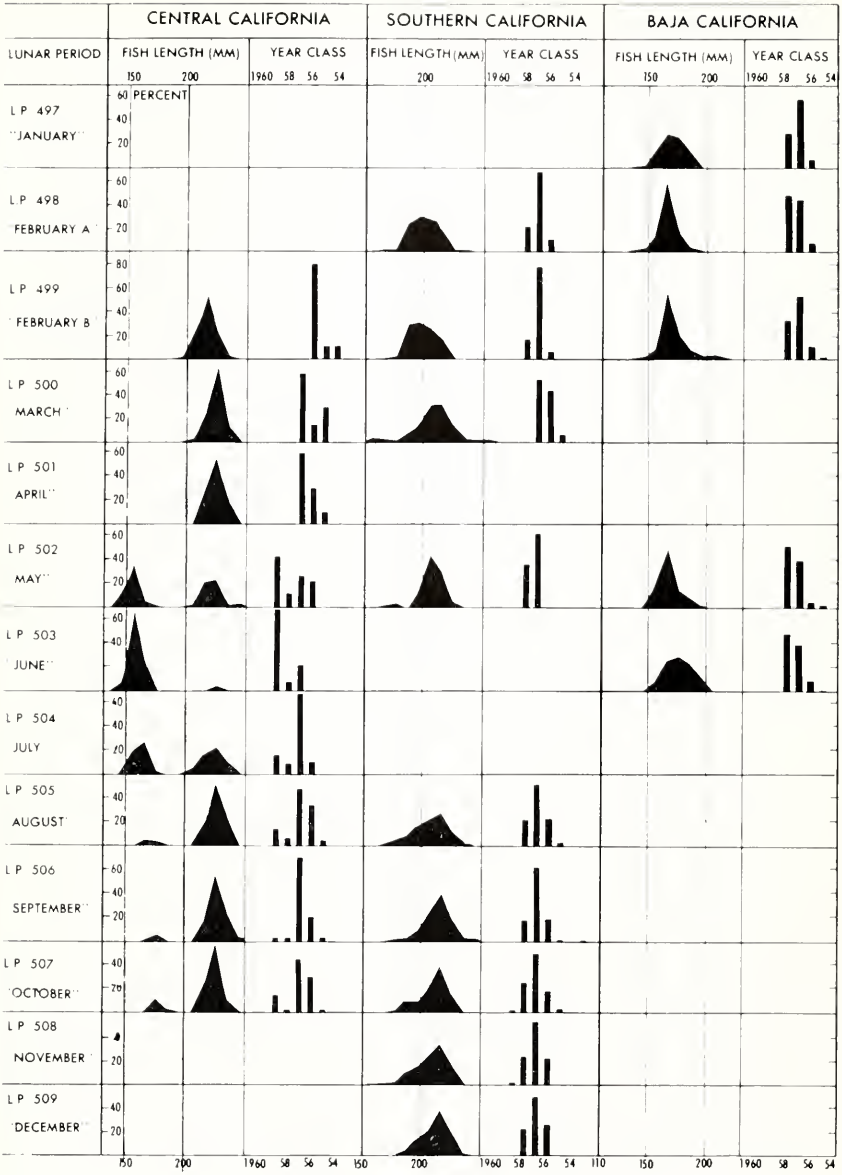

FIGURE 2. Percentage length composition of sardines sampled during the 1960-61 commercial season by region of capture. Data are plotted at 10 mm intervals.

between "February B" and "March" but no increase subsequent to this. A group of smaller fish became evident in "May" and its mode had advanced 24 mm (154-178) by "October." The small group was made up of 1959 class fish together with a few 1958's. The larger group contained mostly 1957, 1956, and 1955 class fish plus some 1954's in "February B."

In southern California, samples were obtained in "February A," "March," "May," and in all the lunar months of the commercial season. There were two length groups present here also but they were not so distinct as in central California. The mode of the larger fish advanced from 196 to 220 mm between "February A" and "December." The mode of the smaller size-group that appeared in "March" advanced into the range of the larger size-group by "December." The age composition of the large size-group consisted principally of 1958, 1957, and 1956 class fish. A few 1955 class fish were evident in "March" and in "August" through "October." Fish of an age corresponding to the small length-group (1959 class) appeared only in "October" and "November."

Baja California interseason samples were taken from "January" through "February B," and in "May," and "June." There was a single mode which remained at 166 mm from "January" through "May," then advanced to 176 mm in "June." Though this mode was relatively constant throughout the period of sampling, the age composition of fish within the distributions varied. The 1958 and 1957 classes alternated in dominance but together made up the bulk of the catch. (Variations in the proportions of year-classes within essentially alike length-frequency summaries are not unusual.) Lesser amounts of the 1956 and 1955 classes were also present.

Age and length data for all months sampled during the Baja California interseason were based on 621 age readings (Table 4). The average length of fish at any age is considerably less in Baja California than in southern or central California.

To estimate the year-class composition of a region's catch during any lunar month, two things are required. The first is an estimate of the number of fish in the landings during the lunar month, the second is a summary of the year-class composition of all fish sampled and subsequently aged during the same lunar month. (An estimate of the total number of fish landed is determined by dividing the total weight of fish landed by the average weight of fish sampled.) This total can then be broken down into year-classes in the same proportions as in the summary of fish that were actually aged. More precise details of the method are given by Felin and Phillips (1948, p. 11).

During the commercial season the average fish caught in central California weighed .3458 pounds and in southern California .2700 pounds. The number of fish caught in Baja California during the season was estimated using the average fish weight of .1596 calculated from the "June" interseason samples, the last lunar month in which the catch was sampled. The "June" average weight was slightly higher than the average weight of .1569 pounds calculated over the entire interseason.

Estimates of numbers of fish in each year-class have been made for the central California commercial season catch, and for the catch off both southern California and Baja California during the southern California season (Table 5). Sardines of the 1957 class made up over half of the season's catch in both California regions. In central California, an additional third came from the 1956 class while minor amounts of 1959, 1958, 1955, and 1954's constituted the remainder. In southern

TABLE 4

Length Composition of Year-classes in Sardine Samples from the Baja California Interseason Catch

Age	0	1	2	3	4	5	
Year-class	1960	1959	1958	1957	1956	1955	Total
Standard length mm.							
140	--	--	1	--	--	--	1
142	--	--	--	--	--	--	--
144	--	--	1	--	--	--	1
146	--	--	1	--	--	--	1
148	--	--	1	--	--	--	1
150	--	--	3	--	--	--	3
152	--	--	1	--	--	--	1
154	--	--	5	1	--	--	6
156	--	--	7	--	--	--	7
158	--	--	10	2	--	--	12
160	--	--	24	1	--	--	25
162	--	--	25	7	--	--	32
164	--	--	25	12	1	--	38
166	--	--	37	13	--	--	50
168	--	--	40	21	--	--	61
170	--	--	20	26	--	--	46
172	--	--	9	10	--	--	19
174	--	--	22	21	--	--	43
176	--	--	8	19	4	--	31
178	--	--	8	17	3	--	28
180	--	--	7	15	5	--	27
182	--	--	4	16	4	1	25
184	--	--	5	16	--	--	21
186	--	--	4	14	2	--	20
188	--	--	3	18	4	1	26
190	--	--	1	13	4	1	19
192	--	--	2	6	5	--	13
194	--	--	1	11	5	2	19
196	--	--	1	9	2	--	12
198	--	--	--	9	2	--	11
200	--	--	--	1	1	1	3
202	--	--	--	2	1	--	3
204	--	--	--	4	3	2	9
206	--	--	--	--	--	--	--
208	--	--	--	--	2	--	2
210	--	--	--	--	1	1	2
212	--	--	--	--	2	--	2
214	--	--	--	--	--	--	--
216	--	--	--	--	--	--	--
218	--	--	--	--	1	--	1
Totals	--	--	276	284	52	9	621
Mean lengths	--	--	168	179	191	196	--

TABLE 5

Age and Year-class Composition of the Sardine Catch in the 1960-61 season

	Catch		*Number of fish in thousands by age and year-class*							
	Tons	*Number*	*0* *1960*	*1* *1959*	*2* *1958*	*3* *1957*	*4* *1956*	*5* *1955*	*6* *1954*	*7* *1953*
Central California										
"July"	--	--	--	--	--	--	--	--	--	--
"August"	1,876	10,808	--	499	528	5,512	3,770	432	67	--
"September"	150	905	--	30	18	646	175	18	18	--
"October"	37	246	--	27	12	126	76	5	--	--
Total Central California	2,063	11,959	--	556	558	6,284	4,021	455	85	--
Percent	--	100.0	--	4.7	4.7	52.4	33.7	3.8	0.7	--
Southern California										
"August"	809	6,391	--	26	1,968	3,400	895	102	--	--
"September"	10,779	78,437	--	1,082	14,770	46,898	15,036	541	55	55
"October"	7,873	57,036	--	1,243	14,727	28,051	11,099	1,865	51	--
"November"	4,130	32,387	--	411	7,909	16,537	7,262	204	32	32
"December"	1,289	9,688	--	--	2,215	5,038	2,435	--	--	--
Total Southern California	24,880	183,939	--	2,762	41,589	99,924	36,727	2,712	138	87
Percent	--	100.0	--	1.5	22.6	54.3	20.0	1.5	0.1	--
Total California	26,943	195,898	--	3,318	42,147	106,208	40,748	3,167	223	87
Percent	--	100.0	--	1.7	21.5	54.3	20.8	1.6	0.1	--
Total Baja California*	7,440	93,225	--	--	46,053	37,290	9,323	559	--	--
Percent	--	100.0	--	--	49.4	40.0	10.0	0.6	--	--
TOTAL	34,383	289,123	--	3,318	88,200	143,498	50,071	3,726	223	87
Percent	--	100.0	--	1.2	30.5	49.6	17.3	1.3	0.1	--

*Period from September 1 to December 31—Aged with age composition of "June."

California, the 1958 and 1956 classes each supplied an additional one-fifth of the catch and the 1959, 1955, 1954, and 1953's each constituted small amounts. The Baja California catch was not sampled during the southern California season, therefore it was necessary to estimate the Baja California "seasonal" year-class composition totals using age composition data of the preceding "June" period. The results of the estimates show the 1958 and 1957 classes together made up nearly nine-tenths of the Baja California total. The remainder was overwhelmingly 1956 class fish but a few 1955's were present.

During the Baja California interseason, the year-class composition of the catch was similar to that derived for the "season" but here the 1958 and 1957 classes were almost equally abundant (Table 6).

TABLE 6

Year-class Composition of the 1960 Interseason Sardine Catch Off Baja California

	Catch		*Number of fish in thousands by year-class*					
Lunar month	*Tons*	*Number*	*1960*	*1959*	*1958*	*1957*	*1956*	*1955*
"January"	59	723	--	--	217	432	65	9
"February A"	872	11,739	--	--	5,635	5,165	939	--
"February B"	1,600	22,313	--	--	7,363	12,050	2,454	446
"March" *	1,557	19,677	--	--	6,493	10,626	2,164	394
"April" †	739	8,742	--	--	4,555	3,497	463	227
"May"	1,996	25,181	--	--	13,119	10,072	1,335	655
"June"	1,437	17,997	--	--	8,890	7,199	1,800	108
"July" ‡	3,268	40,749	--	--	20,130	16,300	4,075	244
"August" ‡	795	9,911	--	--	4,897	3,964	991	59
Total	12,323	157,032	--	--	71,299	69,305	14,286	2,142
Percent	--	100.0	--	--	45.4	44.1	9.1	1.4

* Aged with age composition of "February B".
† Aged with age composition of "May".
‡ Aged with age composition of "June".

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NOTES

AN ORIENTAL GOBY COLLECTED IN THE SAN JOAQUIN RIVER DELTA NEAR STOCKTON, CALIFORNIA

The California Department of Fish and Game has recently collected two specimens of a goby previously unknown in Californian waters. These we have identified as a species common in Japan, China, and Korea, *Acanthogobius flavimanus* (Temminck and Schlegel), often referred to as *A. flavimanus* (Schlegel). The first specimen was taken on January 18, 1963, by Arnold B. Albrecht and Vincent A. Catania (personnel of the Dingell-Johnson Project California F9R, "A Study of Sturgeon and Striped Bass," supported by Federal Aid to Fish Restoration funds), in a midwater trawl in the San Joaquin River off Prisoners Point on the southwest shore of Venice Island. Salinity here is very low, under 30 ppm (chlorides) at this time of year. The second specimen was collected in an otter trawl on March 29, 1963, by E. G. Gunderson, Armand P. Croft, Jr., and Vincent A. Catania, in the Stockton Deepwater Channel just above the entrance of the Calaveras River and just downstream from Port of Stockton. Although approximately 12 miles above the first station, salinity here is slightly greater, measuring about 70 ppm (chlorides) at this period in the year.

The first goby was 123 mm standard length (155 mm total length); the second was 69 mm s.l. (85 mm t.l.). Both have been deposited at Sacramento State College (SSC nos. 35-1 & 36-1). They exhibit close agreement with examples of *A. flavimanus* in the Stanford University Division of Systematic Biology (SU nos. 6574, from Tsuruga, Japan, and 6581, from Nagasaki, Japan) and with the descriptions and illustrations in Temminck and Schlegel (1845, p. 141, pl. 74, fig. 1), Jordan and Snyder (1901, p. 98), and Okada (1961, p. 671, fig. 114).

This species can be distinguished easily from any of the native Californian gobies by the following combination of characteristics: 8 spines and 14 soft rays in the dorsal fin; 46-56 scales in the midlateral series, starting at the upper limit of the opercular opening; about eight diffuse dusky spots, each somewhat larger than the eye-diameter, arranged in a nearly evenly-spaced series down each side, the first three being concealed beneath the pectoral fin, the last forming a more prominent spot at the base of the caudal fin; the sides and back being indistinctly mottled; the upper two-thirds of the caudal fin with about 10 narrow, vertical, dusky, zigzag bands, the lower third plain dusky. It also grows larger than any Californian species except the mudsucker, *Gillichthys mirabilis*, and the longtail goby, *Gobionellus longicaudus;* all three reach about 8 inches.

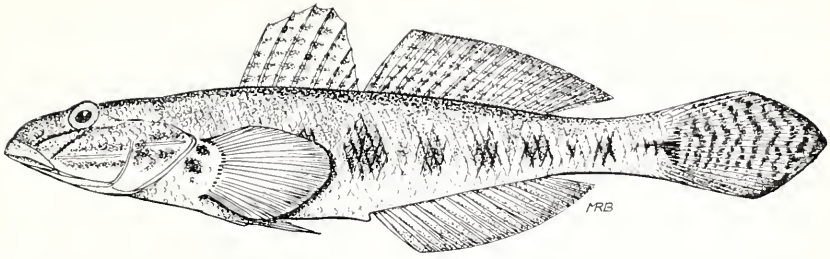

FIGURE 1. Oriental goby, *Acanthogobius flavimanus* (Temminck and Schlegel), 123 mm standard length, taken in the San Joaquin River at Prisoners Point, Venice Island, San Joaquin County, by A. B. Albrecht and Vincent A. Catania. *Drawings by Martin R. Brittan.*

As both our specimens are small, it appears possible that a local breeding population may be getting established. In its native waters, *A. flavimanus* is widely distributed in estuarine environments, ascending a short distance into streams and lakes near sea-level. The Delta region of California appears to be similar to many Oriental estuaries. Okada (1961, pp. 672-3) states under "Habits": "The present species may mature after one year. The breeding season occurs in February and March. The eggs are deposited under sand or muddy bottom of shallow water. The adults live mostly in brackish water around mouths of rivers and sometimes enter into lakes and swamps along seacoasts, and also into rivers. Young live in the mouths of rivers making groups [aggregating] and when the temperature goes down at the end of autumn, they descend into the sea. Foods [presumably of the adults] are small fishes and crustaceans." He also reports on the work of Dotu and Mito (1955) on the breeding habits: "The spawning season extends from January to March in Kyushu. The breeding room, somewhat flat and Y-shaped, with two entrances, is made vertically in the tidal flat deposit. Eggs are club-shaped, 5.5 mm x 0.95 mm in size, with adhesive filaments around the basal end, attached to the wall of the upper part of the room. The incubation period extends about 28 days under the water temperature of 13°C. The newly hatched larva is about 4.6 mm in total length. The larvae, 4.9-12.00 mm in size, spend a pelagic life in the bay, while the young of 15-20 mm in size move to bottom of estuaries. The food is mostly consisting of planktonic copepods." Okada's plate 62 (after Dotu and Mito, 1955) illustrates the embryonic and larval development.

We do not know how *A. flavimanus* was introduced into the Delta, but it is interesting to note than an Oriental shrimp, *Palaemon macrodactylus* (Rathbun), was introduced into the San Francisco Bay area, apparently around 1954, and now is contributing substantially to the commercial shrimp catch (Newman, 1963). The mechanism of this introduction is also unknown, but was probably accidental. Newman (1963, pp. 128-9) feels *Palaemon* larvae may have been carried in a ship's sea water system which was partially clogged with fouling organisms, such as tubeworms and barnacles. *A. flavimanus* could have been introduced in a similar manner.

In view of the eurythermal and euryhaline characteristics of the Gobiidae, and this region's resemblance to many estuarine complexes in the Orient, *A. flavimanus* may establish a substantial population throughout the Sacramento-San Joaquin Delta and San Francisco Bay region. It is possible, also, that *A. flavimanus* may be utilized as a bait fish, as are mudsuckers in southern California.

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Martin R. Brittan, Sacramento State College; Arnold B. Albrecht, California Department of Fish and Game, Sacramento; and John B. Hopkirk, University of California, Berkeley; June 1963.

INTRODUCTION OF *PALAEMONETES PALUDOSUS*, A FRESHWATER SHRIMP, INTO THE LOWER COLORADO RIVER

In 1955, the California Department of Fish and Game began looking for a forage organism to improve the food chain in the lower Colorado River. Studies in Lake Havasu and the River below Parker Dam had shown a lack of forage for small largemouth bass (*Micropterus salmoides*) and channel catfish (*Ictalurus punctatus*).

After a literature search and correspondence with biologists in the eastern United States, the department decided to introduce a freshwater shrimp (*Palaemonetes paludosus*) experimentally into several isolated river ponds. If they became established, they were to be transferred to suitable areas in the River.

This shrimp occurs in freshwater ponds, lakes, and streams of the coastal plain from Florida to New Jersey. It is always associated with cover and is most abundant in dense beds of submerged aquatic plants. In Florida, it is an important food of black crappie (*Pomoxis nigromaculatus*) and largemouth bass under 10 inches long. Mature shrimp range in length from 23 to 53 mm.

The Florida Game and Fresh Water Fish Commission supplied the shrimp for this introduction. Approximately 225 were planted in an isolated pond adjoining Lake Havasu, August 27, 1958, and 1,000 in three ponds in Imperial National Wildlife Refuge, November 1, 1958.

The Lake Havasu pond is the old U. S. Fish and Wildlife Service boat harbor on the west shore about one-quarter mile south of Havasu Landing. The entrance has sanded shut, isolating it from Lake Havasu.

The three refuge ponds are Taylor Lake pond, Picacho pond, and Imperial Camp bait pond. Taylor Lake pond, east of Bear Canyon Bluff (locally called Sheer Cliff), is about 3 miles upstream from the small community of Picacho. It is completely isolated from the River and Taylor Lake, and apparently will remain so. Picacho pond is located at Picacho, approximately 18 miles above Imperial Dam. This pond has a direct connection with the river channel. Imperial Camp bait pond is completely isolated from the River. It is on the Arizona side approximately one-quarter mile above Imperial Dam.

The California Department of Fish and Game and the Arizona Game and Fish Department made cooperative surveys throughout the spring and summer of 1962 to determine the status of the shrimp. Collections were attempted with small-mesh seines, plankton nets, and diving gear. However, simply brushing quickly up under vegetation with a small dip net proved most effective.

The Havasu Landing pond had a limited shrimp population, although there was an abundant growth of sago pondweed (*Potamogeton pectinatus*) and spiny naiad (*Najas marina*). Apparently, fishes controlled the shrimp's expansion. In several areas of the half-acre pond, approximately 25 small sunfish—mostly bluegill (*Lepomis macrochirus*) and some green sunfish (*L. cyanellus*)—were feeding over each square foot of bottom.

No shrimp were found elsewhere in the River or its backwaters from Needles downstream to the Imperial National Wildlife Refuge.

Within the Refuge, the shrimp seemed to be only sparsely established. They were found in two of the original planting areas and in the River and its backwaters for approximately 1 mile upstream from Imperial Dam. When encountered, they were densely concentrated, possibly indicating that only certain areas provide suitable habitat. Considerable cover was available in this area and may have hindered our locating the shrimp. Luxuriant growths of rooted aquatic vegetation choke the shallow areas. Here the principal emergent plants are cattails (*Typha angustifolia* and *T. domingensis*), marsh cane (*Phragmites communis*), and bullrushes (*Scirpus californicus, S. acutus,* and *S. olneyi*). These are abundant the year around. During summer and fall, sago pondweed and spiny naiad grow profusely in the deeper water of the ponds and lakes. Shrimp were most common near shore in sago pondweed and spiny naiad beds, but they also were associated with submerged tree limbs, brush, windblown cane, and cattails.

Taylor Lake pond had a fair shrimp population. The shrimp were found only in association with spiny naiad, although cattails were the dominant plants.

Intensive brushing of cattails, submerged brush, and grass in Picacho pond produced no shrimp. Cattails and bullrushes dominated and they inhibited sampling. We believe few shrimp exist here because acceptable protective cover is lacking. This pond's connection with the River, along with high runoff and flushing action of heavy summer rains, probably explains the occurrence of shrimp in the River.

Imperial Camp bait pond contained the largest shrimp population. The shrimp were collected only near shore where dense overhanging brush, tree limbs, and cattails afforded protection. In the pond, shrimp seemed to school and move from one area to another. Dense populations were found in different locations throughout the survey period. This mobility could account for our difficulty locating shrimp in the River.

Female shrimp in the bait pond were carrying eggs from April 8, 1962 (first date of observations) through September 19, 1962 (last date of observations). Several small shrimp (10 mm long, measured from rostrum to tip of telson) collected July 12, 1962, indicated a hatch earlier in the year.

An analysis of the bait-pond water gave: pH, 8.1-8.3; total $CaCO_3$, 184 ppm; total chlorides, 262 ppm; total hardness, 310 ppm; and total solids, 1,275 ppm. This differed from the side lakes and ponds of the river system, where on the average we found: pH, 8.2; total $CaCO_3$, 132 ppm; total chlorides, 150 ppm; total hardness, 357 ppm; and total solids 850 ppm.

Some utilization of shrimp by largemouth bass in the river system was observed in the spring of 1962. Two shrimp were taken from the stomach of a 7.4-inch bass March 2, 1962, and one shrimp from the stomach of a 4.0-inch bass May 15, 1962. Both fish were collected from No Name No. 2, a small backwater lake on the Arizona side approximately 1 mile above Imperial Dam.

In January and March 1963, 1,100 shrimp from 12 to 38 mm long were taken from the Imperial Camp Bait Pond and transplanted as follows:

January 10

1) 300—Branson's Resort, 5.7 miles above Headgate Dam on the Arizona side.
2) 100—Marina Village, 7.0 miles above Headgate Dam on the Arizona side.
3) 200—Lost Lake Camp, Alligator Slough.
4) 100—Backwater, 200 feet below the Palo Verde Weir on the Arizona side.
5) 100—Palo Verde Drain, second oxbow above the River on the west side of the Drain.

March 22

1) 200—Lake Havasu, 1 mile above Havasu Landing in the Fish and Game Cabin Cove.
2) 100—Havasu Landing Pond (treated previously to remove the fish population).

About five percent of the shrimp were carrying eggs in March, but none was carrying eggs in January.—*Robert P. Hayden, Inland Fisheries, Region 5, California Department of Fish and Game, and Robert D. Ringo, Arizona Game and Fish Department, June 1963.*

PRELIMINARY AGE DETERMINATION OF BLUEFIN TUNA, *THUNNUS THYNNUS*

As part of the California Department of Fish and Game's expanded bluefin tuna research program, we are assessing the age composition of the California catch. We chose scales for our preliminary age determination studies because they were easy to collect, process, and read, compared to such structures as otoliths and vertebrae.

Although untreated scales usually are difficult to read and require much individual handling, we resolved some difficulties by eosin staining, cleaning with potassium hydroxide, and using automatic tissue-processing equipment.

Crossing-over of circuli in the lateral fields and their crowding in the anterior field were diagnosed as annuli. Although scales from small fish exhibited crossing-over, this characteristic seldom was found in large fish because the lateral fields were obscured by scale thickening and circuli erosion. Scales from the caudal peduncle usually were clear and their annuli distinct compared to scales from beneath the second dorsal fin, although these were generally satisfactory.

Our initial study included 247 fish ranging from 51 to 142 cm fork length, collected from commercial landings at Terminal Island during 1961 and 1962. We attempted to sample 10 fish in each 1-cm interval, but several groups were not represented completely. About 50 percent of our samples could not be read because the scales were blistered, saturated with oil, or otherwise disfigured.

TABLE 1

Mean Lengths for Age Groups I through V

Age group	*Length (cm)*	*Length range*
0	57.10	51-69
I	72.08	54-92
II	90.65	77-112
III	106.95	100-128
IV	128.50	124-135
V	142.00	142

Apparently bluefin grow rapidly, increasing in length about 15 to 21 cm per year (Table 1). The mean length at each age compares reasonably well with length-frequency modes determined from market sampling. Additional corroborative evidence, such as growth obtained from tagging experiments, and serial collections of larval and juvenile fish, is needed. *Robert R. Bell, Marine Resources Operations, California Department of Fish and Game, May 1963.*

MIGRATION OF A TAGGED BLUEFIN TUNA ACROSS THE PACIFIC OCEAN

A bluefin tuna, *Thunnus thynnus orientalis*, tagged and released in February 1958 at Guadalupe Island, Mexico, was recovered by a Japanese long-line vessel in April 1963 about 300 miles south of Tokyo. This is the first report of a transpacific migration by bluefin tuna. The minimum distance traveled (via a great-circle route) is 5,800 miles.

The Inter-American Tropical Tuna Commission is concerned primarily with yellowfin and skipjack tuna. However, the senior author

had occasion to tag 121 bluefin tuna from January 31 through February 19, 1958 while aboard the purse-seiner *Columbia* near Guadalupe Island, Baja California, Mexico. Yellow plastic loop tags used by the Commission in their early tropical tuna studies (Schaefer *et al.*, 1961) were employed. Eight of these fish were subsequently recovered between Cedros Island, Baja California, and San Clemente Island, California, all during 1958 (Chatwin and Orange, 1960).

The present tagged fish was released February 2, 1958 at lat. 28° 45′N, long. 118° 15′W and was recaptured at lat. 29° 03′N, long. 139° 42′E on April 23, 1963. Dr. Hiroshi Nakamura, of the Japanese Fishery Ageney, reported it measured between 180 and 185 cm fork length and weighed about 110 kg with gills and viscera removed, which corresponds to a round weight of about 267 lbs. Its precise size when tagged is not known, since individual fish were not measured, because of potential mortality from additional handling. A sample of 25 bluefin from the same school ranged from 71.2 to 97.9 cm fork length, with an average of 91.7. A fish this long would weigh about 35 pounds, according to length-weight data published by Robins (1962) for bluefin, *Thunnus thynnus maccoyii,* from Australian waters. Thus, the fish grew approximately 90 cm and gained approximately 230 pounds in its 62 months at liberty, an average growth of about 1.5 cm or 3.5 to 4.0 pounds per month.

Bluefin tuna have been tagged by other investigators. During the years 1953 through 1956, California Department of Fish and Game scientists tagged 64 bluefin near Cedros Island, Mexieo. In 1962, U.S. Bureau of Commercial Fisheries personnel, in cooperation with the California Department of Fish and Game, tagged 960 bluefin tuna off central Baja California and in the vicinity of the southern California Channel Islands (Flittner and Iselin, 1963; Iselin, 1963). All the tags recovered thus far from these experiments have come from fish recaptured in the eastern north Pacific.

The transpacific movement of bluefin tuna was not completely unexpected. Mather (1960) had reported on two Atlantic bluefin tagged near Florida and recaptured in the Bay of Biscay. Robins (1962) reported movements of as much as 2,000 miles by southern bluefin tuna in Australian waters. Yamanaka *et al.* (1962) reported bluefin have been captured sporadically in the Japanese long-line fishery in the North Pacific Current near long. 160°W, indicating they are not limited to coastal areas.

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—Craig J. Orange and Bernard D. Fink, Inter-American Tropical Tuna Commission, Scripps Institute of Oceanography, La Jolla, California, June 1963.

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Notice is hereby given, pursuant to Sections 206, 207, 208 of the Fish and Game Code, that the Fish and Game Commission shall meet on October 4, 1963, at 9:30 a.m., in the new State Building, 107 South Broadway, Los Angeles, California, to receive recommendations from its own officers and employees, from the Department of Fish and Game and other public agencies, from organizations of private citizens, and from any interested person as to what, if any, regulations should be made relating to fish, amphibia, and reptiles, or any species or subspecies thereof.

FISH AND GAME COMMISSION
Monica O'Brien, Secretary

Notice is hereby given, pursuant to Section 206 of the Fish and Game Code, that the Fish and Game Commission shall meet at 10:00 a.m. on November 12, 1963 in the State Building, 1350 Front Street, San Diego, California, to publicly announce the regulations it proposes to make relating to fish, amphibia, and reptiles for the 1964 angling season.

FISH AND GAME COMMISSION
Monica O'Brien, Secretary

Notice is hereby given, in accordance with Section 206 of the Fish and Game Code, that the Fish and Game Commission shall meet on December 6, 1963, at 10:00 a.m. in the auditorium of the State Employment Building, 722 Capitol Mall, Sacramento, California, to hear and consider any objections to its determinations and proposed regulations in relation to fish, amphibia, and reptiles for the 1964 angling season, such determinations and orders resulting from hearings held on October 4 and November 12, 1963.

FISH AND GAME COMMISSION
Monica O'Brien, Secretary

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